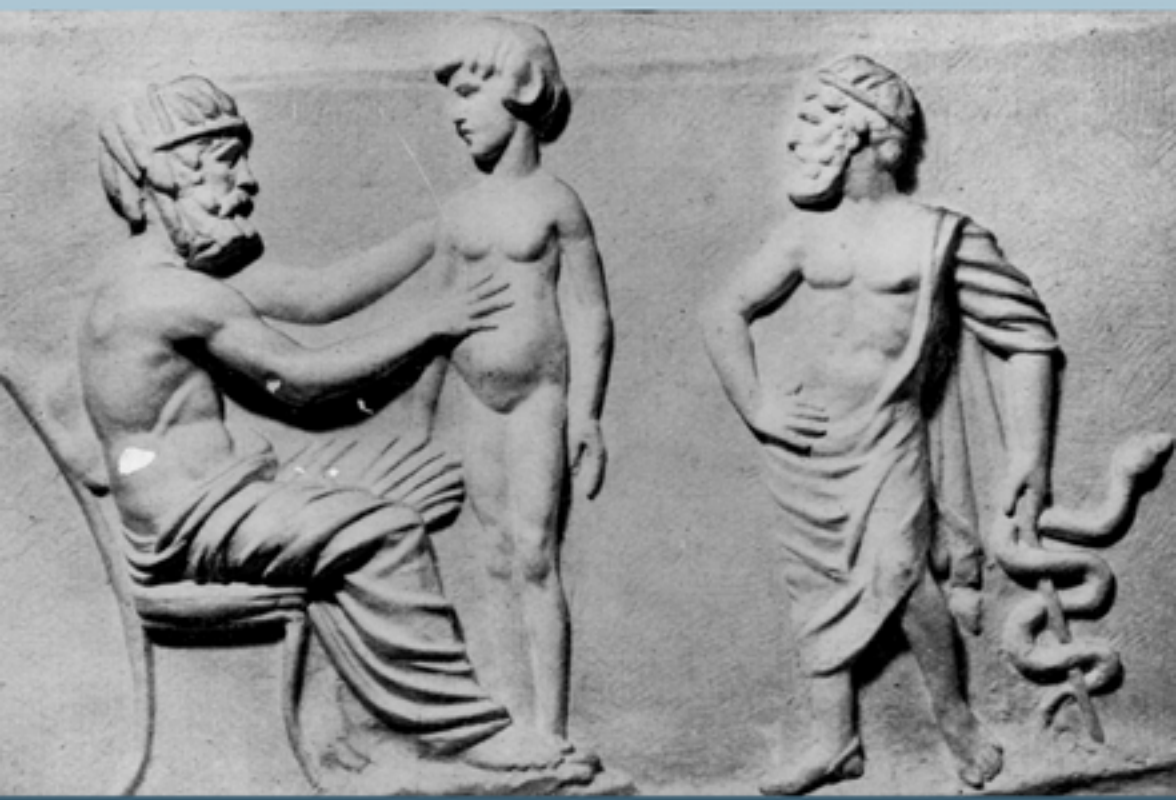

Neurological Concepts in Ancient Greek Medicine

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OXFORD

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FOREWORD

Medical lectures invariably contain the phrase "we now know that. . . ." We are told that, thanks to our powerful tools of genetics and imaging, we are in a completely unique era and on the cusp of unlocking all of the secrets of biology and disease. We are constantly amused by what they thought "back in the day." But, is this true? In fact, is it even remotely possible that our era is any more unique and enlightened than any prior one?

In his compelling work, *Neurological Concepts in Ancient Greek Medicine*, Thomas M. Walshe, an expert neurologist and Greek scholar, weaves 11 essays into a fascinating story of what the ancient Greeks thought about what we now call neurology. His analysis begins with references to the nervous system found in the Homeric epics, which reflect ideas from the 13th century BCE. Although there are no actual medical descriptions in the *Odyssey* and *Iliad*, Walshe scoured the texts for references to the nervous system, which reveal some sophistication about the contents of the skull and nervous system disease, often traumatically induced. The story then leaps forward eight centuries to the Hippocratic literature of the fifth and fourth centuries BCE. A detailed analysis of *The Sacred Disease* and a new Walshe translation of the text follow. *Wounds of the Head* is analyzed next with another new translation of this work from the ancient Greek by Walshe.

Walshe then analyzes the major features of Hippocratic medicine, followed by a consideration of what the ancient Greeks thought about

cognition and aspects of the peripheral nervous system (i.e., nerves and other fibers). The most modern aspect of the book is the Hellenistic pursuit of neuroanatomy, covering the period 323–31 BCE. Walshe's essays end well before Galen's profound effect in the common era on concepts about medicine and neurology. In his final chapter, Walshe translates the Hippocratic *Oath* and muses about the distortions and ironies that mark our current medical experience.

Every physician will be edified by reading this book. Those interested in the nervous system may have a particular penchant for it, but anyone interested in the perspective of history on modern thought will find this a compelling work. In Walshe's self-deprecating preface, he worries out loud about how the classical scholars will rate his work. I believe they will be pleased that a modern neurologist would take this subject so seriously as to study Greek and work on the preparation of this manuscript for over 30 years. In reading this wonderful compendium of essays, one cannot help but wonder if our current concepts of biology, medicine, and neurology are really superior in any sense to those of the ancient Greeks. Perhaps that is Walshe's major message. Perhaps this is not a question that has any real meaning.

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PREFACE

The story of neurology as a discipline begins in the 17th century with Thomas Willis, who opened the door to neurology with his observations of the anatomy, pathology, and clinical aspects of the nervous system.[1] The field was not fully realized until much later in London in 1859 with the founding of the National Neurological Hospital at Queen's Square.[2] In 1892, France saw the birth of clinical neurology as a separate discipline at the Salpêtrière Hospital with Jean Martin Charcot, who was a specialist of diseases of the nervous system. Neurology was defined in the United States by the development at Boston City Hospital (BCH) of a neurological unit, endowed by the Rockefeller Foundation in 1925 to advance academic clinical neurology. Derek Denny-Brown, a New Zealander trained in England in neurology, was recruited by Harvard Medical School in the 1940s to lead the BCH Neurological Unit, which planted the roots of neurology in the United States.[3]

The observations that became the discipline of neurology, however, are foreshadowed in the ancient papyri from Egypt and are certainly found in the ancient Greek world beginning with descriptions in the Homeric epics. The Hippocratic doctors provided a starting point for modern medicine, and although they did not have a firm basis in medical fact, their works reveal the power of their observational skills. Medical practice progressed with the discoveries by Herophilus and Erasistratus in the second century BCE that started the study of neuroanatomy. Galen and other Greco-Roman physicians who wrote a few hundred years later at

the start of the current era discussed neurologic aspects of clinical medicine and built on the previous work. This set of essays discusses the nervous system and its function as conceived during the Homeric period through the early Hellenistic period. Galen and the later medical authors who had more information than the earlier Greeks appear here only as commentators for the earlier ideas.

I began to study Greek at the University of Massachusetts at Boston (UMass Boston) in the classics department as a beginner. It was 1992, and there were only a few classics students in the urban fray of UMass Boston, but the professors were effective in teaching the language, and I became able to translate Greek as a rookie batter tries to hit fastballs. I was enamored by the vitality of ancient Greek literature that has come down through the sources and could not help but pursue more experience. So, the book really began with a sabbatical year at the University of California at Berkeley in 1996, where I was allowed to sit in the classes taught by renowned scholars; the bright young graduate students were way ahead of me and now, after 20 years, comprise the current generation of scholars and teachers of classics. I was more of an (old) fly on the wall, but I was able to learn how to conduct classics research and to translate Greek so I could see for myself what the Greeks were saying and how they said it.

I took my meager skills home after my year at Berkeley and began to read and think of neurologic aspects of the ancient Greek experience. That let me rip out a few abstracts that appeared at the annual meeting of the American Academy of Neurology; then, I was fortunate to have an essay published in 1997. My gradient for publishing the Greek articles created as a hobby was steep. I was also too busy living otherwise to devote time for revisions. After nearly 40 years practicing neurology, I have been able to carve out time to revise the essays. I have hesitated, most of all because I was intimidated by the caustic critiques from the specialists that I imagined would greet a nonclassicist, but being old and thick skinned, I went ahead. Now, I have revisited all the manuscripts and have tried to make them useful and interesting to physicians. So, these chapters are old relics, polished to serve as the substance of this book.

This book is for doctors and others whose medical background includes a neurological interest and curiosity about the ancient Greek ideas concerning the brain, nerves, and functions we associate with modern neuroscience. It provides a summary from a neurological viewpoint of the information that has been published by professional classicists and historians. It harkens back to the ancient compendiums of Aetius or Celsus, which collected other people's ideas into a sort of encyclopedia for a general audience. I include some information about the ancient sources and some background information about the ancient doctors and their practice of medicine.

Specialists in ancient medicine might object that the discussion is not exhaustive and is overly broad, but I hope the references will lead an inquisitive reader to the more thorough professional discussions of the topics. Whole books are written about each of the topics, and most of the Greek sources are easily obtained—although not always available in English translations or even in other modern languages, remaining only in Greek or Latin. There are still editions of Greek sources that use a Latin *praefatio*, and certainly all the old commentaries assume a fluency in both Greek and Latin. The linguistic hurdles can be an impediment for a student of ancient medicine in the 21st century. At any rate, the references in this book can be found with a bit of perseverance in any research library.

This book offers a set of essays, arranged roughly in chronological order, each independent of the others. It is not a "story of neurology" in Greek medicine laid out in a sequential narrative. The quilt of essays stitched together here describes various ancient Greek ideas that pertain to our own ideas of neurology. The essays cover a long time period from Homer and the archaic period to the early Hellenistic era. The span of six centuries will require some overlap in the discussion to follow the subject through each era. The discussion does not include the immense contribution of Galen (second century CE), which would require and has a book of its own. Galen is of course a major source for information about the earlier medical practices.[4]

One purpose of the book is to reveal the origin and the fragility of the ancient source material from which we collate ancient Greek thought

about medicine and indeed from which we get all ancient Greek literature. Most doctors and others not schooled in the classics do not realize that the Greek texts that are translated for us do not come directly from the hand of a Greek author. Verifiable data that anchor our medical assumptions are a necessity for the day-to-day practice of neurology. Likewise, reliable texts, the data of the classical scholar, are a necessity for understanding ancient thought and behavior.

The essays emphasize neurologic subjects but provide a broader background of the Greek thought in which the neurological information sits. The book is aimed at readers who do not read Greek or know about the way Greek medical texts are transmitted, so a philological matrix is inserted in each essay; the fluctuation of vocabulary is described as a way to understand the changes in thought. The changes in the use of the Greek words are put into play in some discussions to develop a lexical transition of meaning and of medical definition.

TRANSLATIONS

I have made two translations of Hippocratic texts that are original in this book, but they rely on the previous renderings done over the last 100 years. The translations of *On the Sacred Disease* and *Wounds of the Head* are literal and in a current vernacular. Both already have good translations available, but I wanted to read them closely and to offer my own rendering. I have used the translations of Jones, Chadwick and Mann, and Francis Adams to check my own translation for the *Sacred Disease*. I translated Jones's Greek text but did look at Grenesmann's German edition. For *Wounds of the Head*, the established text and translation are from Maury Hanson, and I used them as a reliable guide to support my translation.

My translations are literal, staying as close to the Greek as possible so the reader can see what the Greek author said even if the English is sometimes cumbersome. The goal was to provide the meaning of the text as perhaps the Greek author would give it as one of us in our midst.

A professional Greek scholar may not abide some of the liberties I have taken with the text and may rail that it is imprecise, misleading, and not in the line of accepted scholarly practice. I agree. I just translated it so that I could understand what the author was talking about, and I tried to use contemporary diction. As Matthew Arnold said in his advice to translating Homer: "The Greeks are dead." Thus, these texts are now ours to read and to understand. Only those who read them fluently in the original can decide if a translation conveys the meaning and the feeling of the text through the mist that clouds the original from the translation. Greek medical ideas have no reality for us because we have a valid pathology and anatomy. That does not abdicate the responsibility to be as correct as possible in what the Greeks said so our ideas are not introduced into the works. To offer a clear idea of what was said is the goal. I hope I have done at least that, using the guides from other translators from the past.

Classical scholarship is a harsh critic that does not suffer those who appear on the scene with less-than-professional skills. I will be content if I can come close to the faint praise that W. H. S. Jones allowed Francis Adams, a physician and part-time classicist whose translations of Hippocrates are now the ones that are most easily obtained via the Internet. The eminent Jones gave Francis Adams his due:

> Adams' well-known translation is the work of a man of sense, who loved his author and was not without some of the qualifications of a scholar. The translation is literal and generally good, but is occasionally misleading.

I would take that.

NOTES

1. Feindel, William, "Thomas Willis (1621–1675)—The Founder of Neurology," *Can Med Assoc J* August 11, 1962; 87(6):289–296.
2. Critchley, Macdonald, "The Beginnings of the National Hospital," *Br Med J*, June 1960; 1829–1837.

3. Vilensky, J. A., Gilman, S., and Sinish, P. R., "Denny-Brown, Boston City Hospital, and the History of American Neurology," *Perspect Biol Med* 2004; 47(4):505–518.
4. There is a good summary of Galen's contribution to neurology: Rocca, Julius, *Galen on the Brain*, Brill, Leiden, the Netherlands, 2003.

NOTE ON THE REFERENCES

The standard references for Plato (Stephanus) and Aristotle (Bekker) allow any edition to provide the source. For Galen, the case is more difficult because much of his work is not in print or easily available. I have tried to cite the most available books that are at least available in university libraries or can be bought. The Internet has become a godsend for obscure citations, and one only has to type a citation into the Google search bar and there may well be full text renditions available on line.

1

Neurologic Concepts in the Homeric Epics

Neurology as an organized discipline comes late to the history of medicine, but the facts of neuroanatomy, pathology, and neurological function apply to human beings 2,500 years ago the same as they do now. The scientific facts of human biology were, of course, unknown to the ancient Greeks, so the interpretation of medical issues in the ancient world was unlike ours. Ideas that we call neurologic were nonetheless important in the development of ancient medicine, and the diseases and conditions that affected the nervous system occupied the attention of physicians and other thinkers in the ancient Greek world.

Indeed, the awareness and importance of the nervous system in Greek thought is apparent even in the Homeric epics, which have no technical or medical content. Homer described in his epics the details of battle injuries and neurologic conditions that would have been recognized by the Greeks, who were no doubt familiar, either firsthand or by lore, with injury from swords, spears, and arrows. The poet's descriptions reflect the awareness of physical maladies that underlie the traditional combat narrative, and they reveal a keen power of observation that offers distinct examples of injury affecting the nervous system. Applying the assumptions and techniques of modern medical science, it is possible to construct a view of the poetic observations of the Homeric man that allows inferences about how

the archaic Greek audience thought about the brain and how they saw the consequences of injuries affecting the nervous system.

The *Odyssey* and the *Iliad*, the epic poems of Homer, are among the oldest literary sources in Western civilization. They reflect the heroic tradition and culture of archaic Greece. They look back at the Mycenaean era, which flourished perhaps in the 13th century BCE, a time when there were few written records; the extant information comes mainly through archaeological objects. The scanty written evidence from the Mycenaean era comes from clay tablets that were used to account for the goods in the storehouses of large estates. The script on the clay tablets was called Linear B; it has been deciphered, and it records the language of the Mycenaean age.[1]

The written versions of Homer's poems pre-date by hundreds of years the extant Greek medical literature, and they provide a small window into the neurological awareness of the civilization that existed before the advent of classical Greece. Homer was not a historian, so his poems transmit the embellished mythopoetic stories that he was telling; they extol the legends of glory, real and imagined, rather than a historical narrative of the events. Some passages in the epics contain the earliest descriptions recorded in Greece of neurological maladies.[2] The vivid scenes of combat and injury bring us a glimpse of the physical experiences from which the later medical writers conceived their *logo theoreta* or constructed understanding of medicine to which they added their clinical observations to develop Greek medicine of the fifth and fourth centuries.

THE PERIOD AND THE POEMS

The Homeric texts describe implements and customs similar to those found in Mycenaean ruins of the Bronze Age (1400–1200). After the fall of Mycenae, a Greek Dark Age left no written history and few archeological remains from which to deduce its nature; the Homeric epics evolved during this obscure period and contain linguistic traces of the earlier Bronze Age culture. The *Odyssey* and the *Iliad* originated as oral songs composed and sung as inspiration and entertainment. The Homeric poems and probably

their precursors were sung by rhapsodists to audiences who knew the basic stories and reveled in the excitement of the myths. They bring to us a heroic view of archaic Greek attitudes about the way men lived life and excelled or suffered. The stories found in the epics passed by word of mouth after the Mycenaean age down to the eighth century BCE, when they became the songs of Homer.[3] There have been centuries of scholarly speculation about the details, transmission, and final composition of the Homeric poems.

It is important here merely to realize that these epics were composed in an artificial, specialized dialect driven by the dactylic hexameter, which is their strict basic rhythm. The language used in Homer's work was not the routine spoken language of any Greek people at any time. Rather, the epics were composed with several dialects, in forms that cross the development of the language, and with a peculiar vocabulary.[4] Although most of the material in the poems is derived from the eighth century BCE or slightly earlier, there are vestigial elements from Linear B, the Mycenaean script. For example, the genitive case endings (-οιο, -αο, and -αον) and the avoidance of vowel contractions are datable to Mycenaean times. The datives in -εσσι and the thematic infinitives in -μεν are also linguistic markers of the Mycenaean heritage.[5] A *w* sound, part of the Linear B syllabary, was written by the digamma *F* in very early inscriptions. The digamma does not occur in the written texts of Homer, but its phonetic presence affects the meter in over 2,000 instances as a sign of the ancient linguistic origin of the work. The poems also contain certain stereotypical descriptions or epithets, such as "silver-studded sword" and "bright-helmeted Hector," that have their origin in the language found in the Linear B tablets. In some cases, the words used are ancient, but they form a convenient metrical unit so may have been preserved in the transmission by later singers. Specific military vocabulary is helpful in dating some passages when the words are recognized as from the past. There is, for example, a description of the Mycenaean body shield defined as a huge, tall implement that beat on the neck and ankles of Hecktor as he withdrew from battle[6] (*Iliad* 6.117f[7]). Akhilleus, a Mycenaean name, is the hero of the *Iliad*, suggesting that the story dates from that time.[8] Therefore, we can assume that the Homeric epics represent the origins of

Greek culture expressed as a constructed story with a linguistic amalgam derived from many different stages of the oral tradition as it evolved over hundreds of years.[9]

The *Iliad* was probably first written down at the end of the eighth century, just about the time the Greek alphabet was becoming popular; the *Odyssey* was written later, perhaps at the beginning of the seventh century. No one knows the details of the monumental composition of the epics, but the finished work is attributed to a "Homer," who probably wrote them down (or had them written) as he perfected oral presentations from which he made his living as a rhapsodist.[10] The text that we read today is from manuscripts copied and preserved by scribes in the 10th century CE, who probably had access to older texts than are extant. The origin of the exemplars, the oldest copies, of the two epics is a vexing question, but they were mostly intact by the sixth century BCE, then codified in writing for use at festivals and special occasions to preserve a standard performance that was expected by the Athenian audiences.[11]

The Homeric epics are neither historical nor medical texts; they are orally generated, mythopoetic, warrior-age poems that reflect the awareness of everyday events and heroic events as conceived in the archaic Greek period. We can recognize, however, neurological events as we read the stories of the heroes. One way an author reveals his understanding without direct commentary is by the vocabulary he uses and by the way he tells his stories. Because there are no direct statements about medical matters in Homer, we can only infer from the language of the poems themselves the range of neurological understanding that seems reasonable to us now. The way that Homer described injury reveals the attitudes, sometimes quite fanciful, transmitted through the oral tradition and understood by the audience during the archaic period and beyond.

THE NEUROLOGIC DESCRIPTIONS

The concept of a brain, ἐγκέφαλος (*enkephalos*), as an organ of specific nervous function was not defined in Homer. The compound word

(*en* "in" + *kephale* "head") merely indicates the contents of the skull. Its characteristics were derived superficially from battle injury and the slaughter of animals, not through any method of inquiry or by dissection. The word *enkephalos*, which we can render as "brain," appears seven times in the *Iliad* and three in the *Odyssey*, in each instance with reference to trauma to the skull. In these passages, Homer illustrated his concept of the brain's structure and its importance.

In two cases, the enkephalos is said to "flow," *rheo*. The first example from the *Iliad* describes an oath proposed to end the hostilities by allowing Paris and Menelaus to determine the outcome of the Trojan War by single combat. This type of warrior oath was a serious expression of intent, and its description demanded the most solemn choice of vocabulary and imagery. The brain provides a physical basis for retribution if the oath is violated:

> Zeus, greatest and most glorious, and other immortal gods, whosoever first would begin hostilities in violation of the oaths, may their brain flow on the ground like this wine, both theirs and their children's, and may their wives be enslaved. (*Iliad* 3.298–301)

The head was considered to be "holy with the potency by which to swear and make appeal and was thought to contain the diaphanous *psyche* within."[12] The head was associated with the part of the human that continued after death and with the generative life force itself.[13] Homer did not associate any specific function to the brain itself but to the head in general. The oath also tells us something about the Greek temperament and the cultural view of collateral retribution.

The second passage from the *Odyssey* describes the cranial contents that pour out when the Cyclops dashes a sailor's head just before devouring him:

> . . . the brain flowed on the ground, and wet the earth. (*Odyssey* 9.290)

In this passage, the "flow" concept is supplemented by the description of wetting the earth. From these two passages, one can infer that the poet

was aware that there was (cerebrospinal) fluid in the head because there is no mention of blood in either case to account for the use of the vivid verb *rheo*.

In the next group of descriptions, the enkephalos is the target of a weapon or blow in combat. There are three formulaic descriptions in the *Iliad* linking the enkephalos to the verb *palasso*, which means to "spatter, splatter, or spray." The words describing the enkephalos are used verbatim in each passage to describe the consequences of a spear that penetrated the helmet and shattered the skull. The perfect tense of the verbs used here implies an act that is completed and final—fatal.

> This time the bronze helmet did not hold, and cutting through it the spear smashed the bone and the whole brain was spattered inside; thus he stopped him in all his fury. (*Iliad* 20.398–400)[14]

There is no mention of blood in these passages as the cause of the fluidity of the friable brain. The main anatomic elements appear to be what we now know as the cerebral spinal fluid and the gelatinous brain tissue.

The verb *palasso* also appears in the *Odyssey,* not embedded in a formula but used independently. Athena predicts what will happen when Odysseus confronts the suitors who have been exploiting his family:

> And I think that some of the virile suitors who are eating away your livelihood will spatter the broad pavement with both their blood and brain. (*Odyssey* 13.394–396)

In this passage, the blood and brain are clearly separated by the sentence's emphatically paired construction and presumably they were perceived as separate sources for the spatter. Again in the *Odyssey*, the one-eyed monster, Polyphemus, who has been blinded thanks to the guile of Odysseus, expresses his desire to find his oppressor and kill him so that

> his brain might be scattered in pieces all over the cave everywhere upon the ground. (*Odyssey* 9.458–459)

The Greek verb *rhaio* used in this passage means "to disintegrate or break into pieces." This bit of lexical specificity presents a clear image of the brain as a friable tissue rather than merely a liquid.

There are also images of the brain and the blood spilled together through the head injury. Here is the description of the death of Hippothous, who was killed while arrogantly dragging the body of Patroclus around the battlefield:

> But the son of Telemon rushed right past the clustered soldiers and at close range put his spear through the crested helmet with its bronze cheek guards. The large spear point powered by his heavy hand ripped through the crested helmet then the bloody brain spurt out through the wound around the spear. (*Iliad* 17.293–296)

The injured enkephalos is the subject of the verb *anedramen*, which implies an upward flow or motion. The action described here was evidently not only flowing but also pumping out of the wound, perhaps with arterial force.

The last two examples of Homer's treatment of enkephalos come in graphic battle scenes in which the brain is used as a landmark to describe the trajectory of a spear. Here, Idomeneus has just hit Erymas in the mouth with his spear:

> . . . and clean through passed the spear of bronze beneath the brain, and split apart the white bones; his teeth were shaken out, and both his eyes were filled with blood; up through the mouth and nostrils he spurted blood as he gaped, and a black cloud enfolded him. (*Iliad* 16.346–350)

The brain had not been hit directly but it was specifically mentioned to indicate to Homer's audience precisely where the spear hit to cause such damage. Homer revealed a clear awareness of the associated anatomy, and in this case the injury seems to us most like a high cord or brainstem lesion.

The lethality of a head injury is stated directly in the description of the death of Nestor's horse. The horse is said to writhe in the agonal moments, suggesting terminal posturing or dystonia.

> But one horse was destroyed. Godly Alexander, husband of fairhaired Helen, struck it with an arrow, right on the top of the head, where a horse's forelock grows on the head; this is a most deadly spot. Suffering as the shaft entered into its brain the horse reared up, and spooked the other horses with its writhing on the bronze shaft. (*Iliad* 8.81–86)

There are in all 31 fatal head injuries in the *Iliad*.[15] The brain was usually not described, but the forehead was a favored target, as was the case with Nestor's horse. The tenor of the *Iliad* and the intensity of description are illustrated by the following passage in which Menelaus kills Peisander:

> Then [Menelaus] hit his forehead above the base of the nose. The bone cracked and both his eyeballs fell, all bloody, to the ground at his feet; he doubled up as he fell. (*Iliad* 13.615–618)

These lines are as grisly and as violent as anything ever written. Current censors in schools might request a warning label for the Homeric epics if they only knew them.

Another graphic example tells how Patroclus killed Erylaus with a stone to the head. There is no mention of brain here, but the result of the blow is typical of the fatal head injuries in the *Iliad*:

> But then he hit his attacker, Erylaus, with a stone in the middle of the head, and his whole skull was split in two inside the heavy helmet. He fell face down on the ground and life-crushing death enclosed him. (*Iliad* 16.411–414)

The 10 instances in which the cranial contents are directly mentioned and the many cases in which the head is injured without mention of the

enkephalos provide us an image of the Greek concept of the brain's vulnerability, quality, and relationship to the other structures in the skull. Homer described the enkephalos as an intracranial entity using specific words that imply fragility and fluidity. The enkephalos appears in formulaic passages displaying the influence of the digamma and the archaic endings suggesting that the concepts had been well established early in the oral transmission of the poems.

The head and brain were seen to be a seat of viability itself, and they were revered enough to provide a graphic and physical symbol for guaranteeing oaths.[16] The neurologic function of the brain as we know it was not at all part of the Homeric epics. The traditional translation of enkephalos as "brain" conveys a more specific image to us than to the Greek audience who heard the poems. The archaic Greeks had no notion of neuroanatomy or pathology, and their observations of the result of head injury were purely descriptive. There was no coherent idea expressed about the underlying basis of the head trauma.

OTHER HEAD INJURY

Concussion and syncope were also described in the Homeric poems, but mental function was not specifically associated with the head or enkephalos. Injuries to the head were known to cause alterations in mental status. Mental activity was conceived as coming from several entities (*phrenes, thumos, psyche, noos*) that were used to describe aspects of the mental status (Chapter 8). These mental subcategories are not synonyms, and they connote differences in alertness, emotion, and awareness. Consciousness depends on a balance of all the mental faculties, and loss of consciousness depends on the status of the mental entities. Often, the same words are used to describe loss of consciousness as to describe death.[17] Loss of consciousness usually occurs after the psyche leaves the body, but if one is revived after the exit of psyche, it is *thumos* that is said to return.[18] The terms *psyche* and *thumos* are equated in a unique passage describing the fall and recovery of Sarpedon. His *psyche* exits the body after his wound.

His revival comes from a breath of wind. The passage ends declaring the *thumos* as an entity, also lost in the injury, to cause the unconsciousness. He is struck

> . . . and his vitality [*psyche*] left him, and a mist spread over his eyes; but he came to as the North Wind blew over him and he revived although he had miserably breathed away his spirit (*thumos*). (*Iliad* 5.696–698)

The archaic Greeks realized several etiologies could cause syncope, and it was often not from head trauma. When Aeneas was hit with a stone that shattered his hip, Homer described his response: "Black night covered his eyes" (*Iliad* 5.310). We would say "he blacked out." The same description was used for head trauma to describe Hector's concussion, which was caused by a spear deflected by his helmet (*Iliad* 11.356). Another nonfatal head injury occurred when Euryalas was hit on the cheek in a boxing match and lost consciousness. In this case, the mental state was described by a participle, *allophroneon,* a word that may combine[19] ideas of "crazed" and to "have understanding" and is usually translated "dazed" (*Iliad* 23.698). The third case of nonlethal head injury involves Eumelus, who had the wind knocked out of him during a chariot race. Athena broke his rig, so the horses diverged and he wrecked:

> He was hurled from his car beside the wheel. He skinned his elbow, mouth and nose and bruised his forehead above the brow, his eyes teared and he could hardly speak. (*Iliad* 23.394–397)

Eumelus also became speechless; literally, the formulaic line says: "His strong voice was stopped." Language failure is not described in the poems, but speechlessness is described in a formula in other instances. Homer called the loss of speech *amphasia*, but his meaning is different from that of *aphasia* as used now. Homer used the same formulaic line to describe the lack of verbal reaction by a soldier when Menelaus told him of the death of Patroclus (*Iliad* 17.695). The line was used again to describe Penelope's speechlessness when she heard of the plot to kill her

son, Telemachus (*Odyssey*, 4.705). One can deduce then that *amphasia* designated an emotional state of speechlessness more like aphemia than our current idea of aphasia.

Homer described only one case of a broken neck. Elpenor, the youngest but not the smartest of Odysseus's men, broke his neck by falling from Circe's roof. He went to sleep drunk ("heavy with wine"). When he awoke, he forgot he was on the roof and stepped off. The passage describes the exit of the *psyche* as well as the neck broken from the spine:

> He broke his neck away from the spine and his soul (*psyche*) descended to Hades. (*Odyssey* 10.559–560)

Other injury to the neck and its vessels during battle occurs several times in Homer. The prime target for a warrior's spear was the area of the neck behind the jaw and under the ear. Only one case describes "dark blood gushing up" from the neck wound (*Iliad* 7.262). The *ana* in the compound verb *anakeio* (gushing up) perhaps implies the upward flow as in an arterial bleed, but the darkness of the blood may indicate jugular flow. In the other cases of wounds at the same place in the neck, bleeding is not described and the victim drops instantly. These last injuries are more like spinal cord trauma rather than carotid artery injury. For example, when Teucer stabbed Imbrius with a spear behind the jaw and under the ear, Imbrius fell dead like a tree cut down in the woods—no blood here (*Iliad* 13.177–181). Paris used the same bloodless tactic to kill Euchenor, from which *thumos* leaves the dying warrior (*Iliad* 13.671).

Other neurological phenomena are found in the poems that show the degree of awareness and observation the archaic Greeks had available to illustrate their stories. When Telemachus visits, Menelaus' wife (the famous Helen) has an idea to enhance an otherwise-dreary soirée with a wonder drug added to the wine (*Odyssey* 4.219–238). The drug was designed to eliminate "all the pain, banish anger, and to obliterate misery." The drug came from Egypt "where the earth bears the greatest supply of drugs either favorable or toxic." The nature of the drug is not known, but it was probably not opium, which is not attested until

much after the *Odyssey* was composed. The Egyptians were known to use additives to enhance the effect of wine, and the allusion may reflect the general awareness of Egyptian pharmacology rather than point to a specific drug.[20] Nonetheless, the archaic Greeks had some inkling of mind-altering drugs, and as the story goes, Helen's idea was a success.

Homer described what we could call nystagmus when the god Apollo hit Patroclus, who was killing the Trojans heroically:

> But Apollo stood behind him and struck his mid back and his two broad shoulders with the flat of his hand, and his eyes jiggled. (*Iliad* 16.791–792)

Patroclus remained conscious, but later in the fray

> blindness[21] seized his mind and his glorious limbs were disabled under him and he stood stunned. (*Iliad* 16.805–806)

The Greek verb translated as "jiggling" is *strephedinethen*, which combines *strepho*, a word used to describe turning the horses in a chariot around (e.g., *Iliad* 8.168), and *dineo*, which is used to indicate a scanning movement of the eyes (*Iliad* 17.980). The use of the dual *osse* for "both eyes" implies symmetry and bilaterality rather than a skew or ocular motor palsy.

There is one case in the *Iliad* that seems to describe a peripheral nerve injury. Homer told about Teucer the bowman, who aims an arrow at Hector:

> . . . as Teucer was drawing back his bowstring, Hector with the flashing helmet, hit him on the shoulder where the collarbone separates the neck and the chest, a very dangerous place; that's where he hit him with a jagged rock while Teucer concentrated on his target. His bow string broke and his hand grew numb at the wrist and the bow fell from his hand; he dropped to his knees and settled there. (*Iliad* 8.324–329)

There are three peculiar cases in which Homer described the period before death with abnormal neurologic features. The first case is trauma to the neck causing agonal contraction of the jaw. In this case, the injury was to the posterior neck, and we might speculate to the brainstem.

> Phyleus' son the famous spearman coming in at close range stabbed him [Pedaeus] with his sharp spear in the back of his head so the bronze tip went clear through between the teeth and it cut out the tongue at its base. He fell in the dust and his teeth clamped onto the cold bronze. (*Iliad* 5.72–75)

Another case is that of Eurymachus, who was shot with an arrow by Odysseus in the chest just beside the nipple. He fell and had what could be a tonic clonic seizure.

> Then he dropped his sword to the ground and doubling up he fell on the table knocking the food and the double handled cup to the ground. Overcome with agony of soul (*thumos*) he beat the earth with his forehead and kicked with both his feet so the chair shook and mist descended to his eyes. (*Odyssey* 22.83–87)

The last case of Mydon ended in a peculiar way:

> Then Antilochus, attacking stabbed him in the temple. He gasped then fell out of his fine chariot head first into the dust right on his head and shoulders and there he stuck in deep sand for a long time till his two horses pushed him to the dusty ground by butting him over. (*Iliad* 5.584–589)

The image of a warrior stuck headfirst, rigid in the sand may be a bit of an epic exaggeration, but one could imagine it as opisthotonos or decerebrate rigidity embellished with typical Homeric flair.

THE CASE OF DISEASE

The observations of injury provided well-established awareness of the effects of trauma on the body for Homer and his audience, but internal illness was hardly addressed. Apollo was of course responsible for the disease that starts the Iliad but it is distinctly unheroic to be ill, so the nature of the genre would naturally limit the discussion of any internal diseases. There are, nonetheless, eight instances where Homer used the word for "illness," *nousos*.[22] The word appears only in the singular, perhaps suggesting that Homer and his audience conceived of a single etiology for internal disease: a curse of the gods. This concept is stated directly in the *Odyssey* when his fellow Cyclopes responded to Polyphemus's call for help. He tells them he has been blinded by "No one," the crafty pseudonym Odysseus had assumed. His giant comrades replied to Polyphemus's deluded whining:

> If you are really alone and no one is attacking you, then it's not possible to escape the disease of a powerful god so you'd better pray to your father King Poseidon. (*Odyssey* 9.410–412)

Later, Greek medicine took great effort to replace, with more physiologic ideas, the prevailing archaic belief that the gods caused illness. Further chapters discuss the attitudes of the Hippocratic physicians and their conception of neurologic phenomena. We might note that such magical thinking was not entirely abandoned in the classical age spiritualism and religion, and the influence of the gods persisted in Greek medicine throughout antiquity. By the sixth century, however, another medical direction began to focus on natural causes as the explanation of the universe and man himself.

NOTES

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2

Hippocrates and the *Corpus Hippocraticum*

The *Corpus Hippocraticum,* the medical writings attributed to Hippocrates of Cos, is a library of about 60 works by different authors, composed mostly between the late fifth and the fourth centuries BCE. There are, of course, no autograph works and no recorded dates, so the chronology of each text is inferential. Our extant sources for the texts are from medieval manuscripts that were copied centuries after Hippocrates. The information that we have about the Hippocratic practice of medicine rests primarily on the collation of the extant manuscripts, ancillary information about the content from later writers, and scholarly interpretation of the differences in the manuscripts.

The unresolvable question of which texts were written by Hippocrates of Cos has been debated since they were collected. Galen, who wrote in the second century CE, made his choice based on which texts he thought were good enough to be from Hippocrates himself. A reasonable view sees the thoughts and the teaching of Hippocrates embedded in many of the books of the *Corpus Hippocraticum* but not necessarily coming from his own hand. In fact, the *Corpus* contains texts that follow the Cnidian medical methods, which had nothing to do with Hippocrates.

The *Corpus Hippocraticum* represents the major extant source for our knowledge of the practice of Greek medicine before Galen. Its authors

revealed the rational art and technique that supported medical thinking in fourth-century Greece.[1,2] The medical texts have no unitary doctrine and no uniform literary style except that they are written in the Ionic dialect. Books in the *Corpus Hippocraticum* were written for a variety of purposes and for different audiences. The collection preserves textbooks to guide medical practice (e.g., *Wounds of the Head, Fractures, Joints, Diseases I–III, Aphorisms*, etc.), and it contains lectures or essays of more abstract medical interest (*Nature of Man, The Art, Decorum,* and *Precepts*). Some authors have written philosophical texts that attempt to reconcile medical notions with the ideas of natural philosophy (*Nutriment, Regimen I, Breaths*), and others have produced polemic texts that separate the natural from the supernatural interpretation of the world (*On the Sacred Disease, Ancient Medicine*). Research notes, lecture notes, case studies (*Epidemics*), and other miscellany (*The Oath*) fill out the collection. The contents of the collection influenced the practice of medicine through the 1800s, being venerated by Galen in the second century CE, and it is through Galen that the Hippocratic ideas persisted in late antiquity and beyond. The practical value of the Hippocratic work is gone now, but they provide an insight into the understanding of medicine and science as defined by the Greek physicians.[3] The texts are remarkable for the acuity of clinical observation even in a time when there was no "evidence base" for medicine.

DATES, SOURCES, AND TRANSMISSION OF THE HIPPOCRATIC TEXTS

The dates of the original texts have been constructed by scholars from various threads of evidence that place them in a calculated time slot. One clue regarding the date of composition of the texts is the analysis of writing style used by the author. The style and syntax of the texts included in the *Corpus* differ because there were many authors who wrote for different purposes at different times. The earliest texts used an epigrammatic style that may reflect the concrete thought favored by the itinerant Greek doctors of the late fifth century. For example, the aphoristic texts,

Prorrhetic I (440 BCE), *Prognostic* (415 BCE), *Aphorisms* (415 BCE), and *Coan Prenotions* (410 BCE), are considered to be among the earliest. The epigrammatic style reflects the method of early fifth-century philosophers like Heraclitus, and it conveys concentrated ideas without the exegesis that develops in later writing.[4] The texts written later express medical observations with more theoretical context and in the rhetorical style of the sophists, which dates them roughly between 427 and 400 BCE. Works later than 300 BCE have a verbosity and tortuosity of expression that is characteristic of the Hellenistic period.[5] Another set of clues lies in the grammar and diction found in the texts.

There are also external clues to the date of the texts that use the information from the later datable lists, commentaries, and lexicons that contain Hippocratic references. The citation in a source defines a date, a *terminus ante quem*, before which the text had to be written. Another estimate for the date of a text uses the content to identify specific ideas that were datable. Internal evidence of this sort can provide an assumption that the text was written after the doctrine was defined providing a *terminus post quem* setting the date after the idea was established. Despite the careful scholarship, the dates for many of the Hippocratic texts are rough estimates. The texts generally date between 450 and 350 BCE, but some outliers are later.

MANUSCRIPTS IN THE *CORPUS HIPPOCRATICUM*

Because of the stylistic interference with the dialect in the transmission of the originals in the manuscripts, the specific dialect and style of the Greek written by the Hippocratic doctors has been lost. The earliest Hippocratic texts were probably written for the most part in the Attic Greek dialect with some Ionic forms.[6] The later Greek scientific authors used the Ionic dialect but gradually diverged from the Ionic toward Attic, keeping enough of the Ionic to conform to the convention of medical prose. The scribes, in the Middle Ages, felt compelled to write pseudo-Ionic forms in attempts to correct the text, which they thought had been Atticized.[7] The uncertainty of the original dialect does not obscure the content.

A crucial step in understanding the Hippocratic texts, or any ancient literature, is the establishment of the most authentic text from the existing medieval manuscripts. Scholars have worked for centuries to collate, authenticate, and edit the manuscripts that were copied by medieval scribes. Multiple copies of the texts have been transmitted, perhaps from different original texts, by different scribes, so the extant manuscripts vary in the detail of their content. In general, the earliest manuscripts transmitting Greek literature date from the ninth century CE. There are papyrus fragments taken from the dry parts of Egypt that date as early as 300 BCE, but most of the papyri come from the second to third century CE.

The transmission of medical (or other technical) writings differs significantly from the transmission of literary texts because the copiers of the medical books, the scribes, were concerned with the sense of the text more than the style or the charm of the author. Moreover, the medical texts were used to practice, teach, and learn medicine and naturally would have notes added by those who used them. As the manuscripts were copied, the notes added by the users were not always kept separate from the text as they are in literary works, so the added text became incorporated into the body of the original work. The oldest manuscript containing the Hippocratic texts is *Vindobonensis med* IV (Θ) from the 10th century CE. Two different collections of Hippocratic texts were transmitted in manuscripts. The collections were compiled sometime before Galen. Each has a different order of texts and differs in the texts included. The origin of the collections is not settled, but the texts seem to go back as far as Alexandria.[8]

Modern editions and commentary on the collection

The first known printed edition of the *Corpus Hippocraticum* was produced in 1525 by M. Fabius Calvus of Ravenna, who copied a single manuscript, *Vaticanus Graecae* 278, written in 1512. The Aldine edition was published in 1526 by Franciscus Anulanus and is considered the *editio*

princeps.[9] Emile Littre[10] collated the manuscripts, established a text, summarized the scholarship to date, and between 1839 and 1861 sequentially published a French edition of the complete works in ten volumes. His edition formed the basis for all later scholarship aimed at the *Corpus*. An English translation was published in 1849 by Francis Adams, a surgeon, using Littre's text.[11] Other 19th-century editions in German were done by Ermerins,[12] Reinhold,[13] and Kuhlewein[14] and are still used in the analysis of the text. An English edition from collated manuscripts without commentary was published in the Loeb Classical Library Edition by W. H. S. Jones between 1923 and 1931.[15] The surgical parts of the edition were translated by a surgeon, E. T. Withington,[16] and some works not in the earlier Loeb editions were published by Potter[17] and Smith.[18] Hermann Grensemann edited *On the Sacred Disease*, providing an authoritative text with a comprehensive discussion of the related manuscripts. He also provided a German translation.[19]

THE CONTENTS OF THE HIPPOCRATIC COLLECTION IN ANTIQUITY: HOW DID WE GET THESE TEXTS?

Among the texts published by Littre from the medieval manuscripts, only some are listed in the ancient sources that refer to the collection.[20] The oldest reference to the Hippocratic collection came from Bacchius,[21] a literary scholar in Alexandria in the third century BCE who compiled a lexicon of difficult words from Hippocrates that were used to identify 23 works that he knew. In the first century CE (14–37 CE), Celsus[22,23] wrote an overview of medical information that, by comparing his text with similar passages in Hippocrates, provided evidence of 25 works known to him at the time. In the middle of the first century CE, Erotian wrote a dictionary of Hippocratic medical terms[24] in which he supplied a list of ancient commentators,[25] of which Herophilus was the first. He also provided an index of texts by title.[26] *On the Sacred Disease* appears on his list. Unnamed texts can be identified by specific words and phrases found in the dictionary and by adding to the named texts others, that are inferred from the lemma of his dictionary; 49 of the texts found in the later manuscripts appear to have been known to him.[27]

By the third century BCE, especially at Alexandria, the scholars recognized the need to collate and edit the earlier Greek literary texts they had in their library. The text of major literary works, epics, dramas, and others were standardized, the new alphabet was used to record them, and punctuation, accents, and breathing patterns were added. The rules of textual criticism were applied to establish the best texts.

Dioscurides and Artemidorus Capiton, both followers of the Hellenistic literary tradition, produced scholarly editions of Hippocrates, now lost, in the first century CE; these were mentioned in Galen's commentaries. These two scholars developed the concept of "genuine works" of Hippocrates and perhaps their works were the origin of the collection.[28] Dioscurides used his experience with the glossographers, grammarians, and the traditions of Homeric scholarship to make suggestions about glosses and authorship in the medical texts. The scholars altered the text to reflect their notions of the dialect and commented on the insertions that were not original. Their activity caused Galen to criticize their "reckless" alterations of the text, opining that they overdid their changes in the grammar.[29] It is possible that the texts established by Dioscurides and revised by Capiton were the exemplars for the manuscripts we have now.

Galen, who wrote in the second century CE, provided the major sources for Hippocratic scholarship in antiquity, and his commentaries often supply superior reading to the medieval manuscripts either from direct quotations or from his discussion of a suspect text. He also provided insight into the meaning of obscure passages. We have his commentaries on 13 texts, and there are four other commentaries known, but lost. He did not write a commentary about *On the Sacred Disease,* but he discussed the sacred disease without mentioning Hippocrates.[30]

IN SEARCH OF THE HISTORICAL HIPPOCRATES

Information about Hippocrates of Cos himself is limited by the scarcity of reliable sources. We know from Plato that he was a well-regarded physician from Cos and taught for money.[31] Aristotle said that "Hippocrates is called greater not in stature as a man but as a physician."[32]

The pseudepigraphic writings[33] about Hippocrates and his teachings are a combination of fact with fantasy that provides an idealized rendition of his life and professional activity. The biographical texts are from the Hellenistic period and contain 24 letters, a decree made in Athens making Hippocrates a citizen for his devotion to the city during the plague,[34] and two speeches, one by Hippocrates and a long one by his son. The speeches were listed in Erotian, which suggests they were known in the last quarter of the third century BCE.[35] These writings supplied the standard picture of the "father of medicine" by codifying the anecdotal tradition and embellishing it. The dramatization in the pseudepigraphic writings was perhaps stimulated by the anonymity of the Hippocratic books and the dearth of any authentic biographical data on the man. Despite the fiction inherent in the pseudepigraphic material, there is probably some anecdotal validity in the general reputation and activity of Hippocrates. The pseudepigraphic writings were first collected in the Aldine edition of Hippocrates. The letters were contained in manuscripts without the Hippocratic works themselves, but the speeches, the decree, and some letters do appear in some manuscripts with the medical texts. There are also papyrological sources for some of the letters dating from 1AD CE.[36] Letter 19 in the pseudepigraphic material is a discussion of madness that excerpts passages from *On the Sacred Disease*.[37] The pseudepigraphic texts are not biographical sources for the man Hippocrates but are a construction of the icon of Greek medicine.

Three later biographies of Hippocrates depended on the pseudepigraphic information without adding much else. Tzetzes,[38] a "copious, careless, quarrelsome Byzantine polymath"[39] of the 12th century CE, used the biography written by Soranus,[40] a contemporary of Galen, to write a biography of Hippocrates. The biography of Soranus, however, is considered inaccurate.[41] The Suidas, the Greek encyclopedia-dictionary written in the 10th century CE, has an article on Hippocrates based on a separate tradition. The material in the extant biographies is anecdotal at best and suffused with the high regard assigned by the later physicians.

The details of his actual teaching are as elusive as the details of his life. Attempts at determining which of the books were written by Hippocrates

himself have been impossible because there is no text in the collection that is absolutely known to be his. Plato, in the *Phaedrus*,[42] provided a near-contemporary clue concerning what the man Hippocrates thought. Socrates and Phaedrus were discussing the limits of rhetoric:

> S: Do you think that anyone can acquire any appreciable knowledge of the nature of the soul without knowing the nature of the universe?[43]
> P: If Hippocrates the Asclepiad is to be trusted one cannot know the nature of the body either, except in that way.
>
> S: Then see what true nature and Hippocrates say about nature. In considering the nature of anything, must we not consider first whether that which we wish to learn ourselves and to teach others is simple or multiformed, and then, if it is simple, inquire what power of acting it possesses, or how it is acted upon, and by what; if it has many forms, number them and then see in the case of each form, as we did in the case of the simple nature what its action is and how it is acted upon and by what.

Plato said that Hippocrates believed that natural phenomena of the body were linked to understanding cosmic truths and that breaking down complicated systems was the way to get to the multiple underlying etiologies one at a time. But, there is no text in the Hippocratic collection that fulfills this definition enough to establish it as Plato's source. Therefore, there is no standard text by which to judge others as coming from Hippocrates's own hand. *On Ancient Medicine* expresses similar ideas and was used by Littre to identify the "genuine" works, but later scholarship has not found any convincing text that would support the source for Plato's opinion.[44]

Menon's *Iatrica* provides a summary of Hippocratic thought that came from a medical papyrus from the second century CE called *Anonymous Londinensis*.[45] The fragment listed a number of famous physicians and described their principle tenets. The work was probably a student's notebook and not Menon's work or even a good copy of it, and the rendition of Hippocratic medicine is somewhat garbled. The text says that Hippocrates

believed that breaths (gases) arising from the digestion of foods were the basis for pathophysiology. It also says that Hippocrates believed that *pneuma* was the basic element of human physiology. The material in *Anonymous Londinensis* reflects the ideas in *Breaths*, a sophistic exercise with little to suggest a powerful medical presence expected from the hand of Hippocrates. The *Epidemics* I and III seem more plausible candidates for Hippocratic authenticity, but *pneuma* as the physiologic substrate was a concept that physicians other than Hippocrates taught, either independently or under his influence.[46] For example, in the *Symposium,*[47] the physician Eryximachus, while holding forth about love, revealed his medical views, which reflected the attitudes found in *On Ancient Medicine, Breaths*, and *Decorum*.[48,49] There was no mention of Hippocrates.

Although the data from Plato and *Anonymous Londinensis* lack the specificity to use as inclusion criteria, they may be sensitive enough to exclude texts in the *Corpus* that are in conflict with the attributes attested to Hippocrates. Perhaps some of the texts in the *Corpus* were by Hippocrates himself, but there is no philological way to determine which ones. Commentators have routinely determined that the ones with the best medical work were genuine. A recent review of the archetype for a "genuine" work choose *Regimen* I.[50]

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3

A Neurology Text Before There Was Neurology

The Hippocratic text *On the Sacred Disease* is of particular interest to neurology and neuroscience because it describes epilepsy, the disease "called sacred" by the Greeks. *On the Sacred Disease* presents a specific discussion of the clinical features we would recognize as epilepsy, and it provides a detailed discussion of the brain. The treatise, although it was known, was not often discussed or cited in the later ancient medical literature, so its influence on ancient Greek practice seems slight.[1]

The idea of "sacred disease" was established before the Hippocratic texts were written. The term occurs in a fragment by Heraclitus (fifth century) in a typically opaque snippet that has him say "thinking is [like] the sacred disease and vision is misleading."[2] The meaning is not easy to understand, but it may be a metaphor for the tendency for a thinker to be distracted and fall away from his thoughts (as in falling sickness) but to keep trying despite the interruption. The deceptive vision may refer to the failure of the senses if there is an uncomprehending soul. Herodotus (fifth century) also used the term *sacred disease* to describe the madness of Cambyses, the Persian king.[3] It is not certain if Herodotus meant what we know as epilepsy or some other alteration of mental status ascribed to divine origin. Epilepsy was not the only condition defined as sacred in ancient times.

The Hippocratic author of *Airs, Waters, and Places*, a text related to *On the Sacred Disease* in its approach to illness and divine cause, rejected the sacred cause of an endemic malady that affected some Scythian men, often the wealthy ones. The condition caused impotence and made them dress and live as women. The disorder was called a sacred disease, the result of divine intervention against those who were afflicted. The Hippocratic author dismissed its divine origin:

> Now the natives put the blame on to Heaven, and respect and worship these creatures, each fearing for himself. I too think that these diseases are divine, and so are all others, no one being more divine or more human than any other; all are alike, and all divine. Each of them has a nature of its own, and none arises without its natural cause.[4]

He admitted the divine background of all disease but emphasized the expected natural cause of the disorder and concluded that excessive horseback riding (the Scythian men practically lived on the back of their horses) was the cause. The author of *On the Sacred Disease* listed other symptoms that we might diagnose as nonepileptic: "They say it is the attack of Hecate and the assault of heroes when, during the night, fear, terror and panic develop and the victim jumps out of bed and runs outside."

SUMMARY OF THE TREATISE

On the Sacred Disease begins with a screed that proclaims natural cause rather than supernatural influences as the correct origin of illness. Indeed, the antipathy toward mystery mongering or sacerdotalism signals the genuine Hippocratic influence that supported the secular practice of ancient Greek medicine. The author opened his discussion by denigrating the temple practitioners who considered disease to be caused by the intervention of a god and who prescribed treatments of purification, incantation, and baseless prohibitions of food and behavior. The author

attacked them as incompetent, impious, and profit motivated. The disease, he insisted, is no more divine than any other and can be treated with the methods known to medicine, not by religious chicanery.

After completing his attack on the religious healers, the author proposed a rational explanation for the condition. The author of *On the Sacred Disease* explained the pathophysiology as alteration in humors, the effects of wind, and the role of ambient temperatures. Despite the fanciful pathology, we also see in the text precise clinical descriptions of the disorders he observed. The author defined his pathophysiology as the liquefaction of the body and brain, influenced by internal and external events.

The author believed that there are essential liquids (humors) that determine the physiology and pathology of the body. The humors that he chose to use are phlegm and bile. These two fluids may be in various liquid states or a solid state, depending on the status of the body and the environment. The phlegm overflows into the body and brain, cutting off the external air from which we survive and by which we think. The air may also cause cooling of the organs, including the brain, rendering it less responsive if overly cool. The main pathology in the etiology of a seizure is an excess of phlegm, which cools and coagulates the blood and blocks the external air from getting to the brain and body. The severity of the condition is proportional to dose: The more phlegm, the more threatening the disease.

He concluded that the sacred disease is caused by an abnormality of the brain that has not been sufficiently purged of phlegm before or after birth. Epilepsy is caused by flows of phlegm descending from the head in two thick blood vessels that begin in the liver and the spleen; the cold phlegm coagulates the blood and blocks the passage of air carried by these vessels. The author identified the brain as the source of psychological life and of the intellect. A disturbance of the brain leads to two sorts of madness: agitated madness due to excess bile and quiet madness due to excess phlegm.

A collateral pathology is the flux of the bile that causes heating of the body; the bile flows in excess, causing what we might think of as fever. The bile disrupts the body when it is flowing because it causes overheating and

agitation. The brain "seethes" when there is an excess of bile. The flow or "fluxation" is an overflow and a migration of the humor (phlegm or bile) that is "melted" from the body. Think of a runny nose. The disruption of the balance of phlegm and bile is the cause of the illness.

The underlying Hippocratic theme for health is a balance of the humors, just enough and not too much. Disease comes from an excess or dearth of a humor.

The author observed that the winds had a medical effect on patients as, by analogy, it had on other physical systems by changing the ambient temperature. His view made the cooler north winds better for health because they clarified the environmental air rather than creating a muggy haze that obscured the moon and stars. The south wind brought in humidity and excess moisture that encouraged phlegm. He also indicated that the warmer weather was conducive to failed treatments because the heat interfered with recovery.

The author identified the brain as the key organ that caused the seizures and the key organ that controlled cognition. He mentioned what might be an early anatomical experience in looking at the brain of a goat with a condition similar to the malady described as the sacred disease. The goat's brain was described as a malodorous and abnormal structure. The description may be an attempt to provide a structural basis for the sacred disease as a "lesion" in the brain. The description does not meet criteria to call it an experiment or even a scientific gesture. It was just an observation made in the course of daily activity.

The clinical descriptions that the author provided for the sacred disease are the most interesting aspect for us in the 21st century because they resonate with the observations we have also made. Epilepsy often occurs in children, and it is likely inherited from the parents. It seldom appears for the first time after the age of 20 unless it was present before. The attacks are episodic, and they come less often in summer and more often when there is a wide variation in the temperature. The seizures can be major or small depending on the degree of "phlegmopathy." The attack may render the victim speechless and breathless, and he or she loses consciousness. The hands become stiff, the feet kick, the eyes deviate, the mouth foams,

and there is incontinence of bowel. The seizure can be fatal, especially in children and the elderly. In some cases, there is a single episode that leaves a neurological deficit where the phlegm has blocked a specific part of the brain and the patient does not have recurrent seizures. That syndrome sounds more like a stroke rather than a simple seizure, but the author could not take it further. In other cases, the seizures are recurrent and resist treatment.

The symptoms of a bilious attack look more like hallucination and delirium than a seizure in our modern light. The treatment of disease in general and of the sacred disease itself was a prescribed lifestyle, *regimin*. Specific foods, exercise, baths, and other behaviors that retard the disease would be used to wear the malady down, allowing it to be surmounted by nature's healing. The proper treatment regimin balances the dry, wet, hot, cold within the context of the seasons. The treatment literally depends on which way the wind blows. There were no specific suggestions mentioned here by the author, but the concepts of regimin are an essential feature of all ancient Greek treatment.

The author directly rejected the theories that held that the diaphragm and the heart were the seat of intelligent thought and emotion. This author defined brain disease as being no more divine than others and acknowledged that every disease was divine to the extent that it was caused by natural elements (cold, sun, winds), which must be as a background of nature, divine, but every human disease was defined by specific natural cause and so was curable. We can now look at the competition of the secular physicians, the temple healers, who were the target of the author's outrage.

TEMPLE MEDICINE

Greek medicine was a rational and empiric practice, but it was embedded in a religious worldview that encouraged the secular physicians (as is the case today) to at least allow a divine influence behind natural phenomena. The unavoidable acceptance of the divine aspect of the universe and the

belief that medicine was separate from it created a dichotomy from which the Hippocratic author must argue. The role of prayer and religious activity was not scorned but rather endorsed because divinity was the source of the sun, the winds, and everything in nature that construed the background of the known world. The divine origins of nature that persisted throughout antiquity did not interfere with the concept that disease and indeed health was a natural process, understandable by natural phenomena, and independent of any accessible divine management.[5] Religious medical practice and secular medicine coexisted as viable ways to stay healthy and overcome illness. The exhortation against temple medicine in *On the Sacred Disease* came not only because secular methods might be better than temple practice but also because the two were in commercial competition. The secular physicians seemed to have accepted Thales's idea that the "gods are in everything" but did not accept the access to them.

Nature was seen, after the fifth century, as a mechanical dynamic power whose explainable processes were merely one part of the overall divinely created world. Atheism was not well tolerated, so the divine background was kept in secular medicine, but manipulating the supernatural was not accepted in the successful practice of medicine or of any science.[6] The Greeks, similar to modern man, allowed a symbiotic relationship between divine influence and natural phenomena so they could have it both ways up to a point. The gods were present, active, and accessible in the world but not manipulable as the primary solution of illness, and they did not cause disease.

Magical and religious activity, which had been attached to the temples of healing since Homer, remained an important fixture in the medical care available to the Greeks. There were several cults that arose with healing ability, but the best known are the temples dedicated to Asclepius, the son of Apollo, the god of healing. The temples were found all over the ancient world. The power of religious belief is strong; indeed, attempts at divine healing have persisted throughout history despite the overwhelming scientific basis for secular treatment.[7]

We know about temple healing through the inscriptions at the ancient temples, which extol miraculous results of the practice. There must have

been some benefit because the Greeks, not easily bilked, persisted in their emotional, and probably financial, support of the temple practices. In his description of a temple treatment, Galen offered a hint at their value despite his penchant for brutal criticism: "The whole body of Nicomachus of Smyrna swelled excessively and it was impossible for him to move himself. But Asclepius healed this man."[8] Galen also described a case from Pergamum:

> Another wealthy man, this one not a native but from the interior of Thrace, came because a dream had driven him to Pergamum. Then a dream appeared to him, the god prescribing that he should drink every day of the drug produced from the vipers and should anoint the body from the outside. The disease after a few days turned into leprosy; and this disease, in turn, was cured by the drugs which the god commanded.[9]

Another late attestation to efficacy of temple practice came from Rufus of Ephesus, mentioned in the medical book of Oribasius (fourth century CE):

> Also epilepsy is a cramp; therefore quartan fever is a cure of this, so that if (the fever) supervenes afterwards, epilepsy is broken up, while if it comes previously, epilepsy does not befall that man any more. How it happened to Teucer, the Cyzicenean [ca. 100 CE], is worth telling: when he was afflicted with epilepsy he came to Pergamum to Asclepius, asking for liberation from the disease. The god appearing to him holds converse with him and asks if he wants to exchange his present disease against another one. And he said he surely did not want that but would rather get some immediate relief from the evil. But if at all, he wished that the future might not be worse than the present. When the god had said it would be easier and this would cure him more plainly than anything else, he [sc., Teucer] consents to the disease, and a quartan fever attacks him, and thereafter he is free from epilepsy.[10]

The temple inscriptions, which come directly in stone from the fourth century BCE, describe miracles that seem impossible in modern medical

terms. However, even now there are patients who recover without allopathic medical explanation. "Miracle" cures nowadays usually occur in patients misdiagnosed with a serious illness by practitioners who keep quiet about their blunder when the unpredicted recovery shows up in public or at the hands of modern faith healers.[11] The same situation may explain some of the ancient miracle cures. Edelstein rehearsed explanations for the impossible cures that were recorded. The most likely basis for the hyperbole is that they are fabulous stories of a god's power. The people of the time were not surprised at the marvelous outcomes, much like many people today believe the traditional story that Jesus brought Lazarus back from the dead or that the saints were able to cure disease.

The healing visit to the temple was a rather mundane experience compared to the drama that oracles demanded and the mystic ceremonies of other ancient cults. The supplicant came dressed in street clothes and was required to bathe either in the sea or otherwise and to present a sacrifice to the god. The process of healing relied on "incubation," during which the supplicant slept for the night in the temple, where the god would come in a dream or in twilight sleep to effect the cure.

Inscriptions put up in the temple of Asclepius at Epidaurus in the late fourth century BCE testify to the incredible success of the god. They are advertisements for attracting patients, but they must have had some basis in experience. They also show that the gods and their priests prescribed diet, drugs, and surgery along with the supernatural influences to effect cures.[12,13,14] Edelstein, in his study, found no evidence that there were hallucinogens, dietary intervention, or other treatment added to the dream as the central cure. The supplicants were similar to those who might attend the healing revivals today; they were ready to believe. They came to the designated areas for the incubation and slept on pallets. Priests helped them in the process. As a secondary treatment, after the dream, the priests may have prescribed herbs or drugs or even used the knife but that had to be independent of the incubation. When the supplicant awoke from the magic dream, he or she had been visited by the god and had been cured or the remedy had been explained. Temple inscriptions report the successes. Some examples are presented next.

Surgery far beyond the scope of any possible secular practice was dreamed as a cure:

> A man of Torone infested with leeches. In his sleep he saw a dream. It seemed to him that the god cut open his chest with a knife and took out the leeches, which he gave him into his hands, and then he stitched up his chest again. At daybreak he departed with the leeches in his hands and he had become well. He had swallowed them, having been tricked by his stepmother who had thrown them into a potion which he drank.[15]

And, they received drugs with more efficacy than anyone could explain:

> A blind man came as a suppliant to the god. In one eye he had only the eyelids left it was entirely empty, there was nothing in it. Some of those in the Temple laughed at his silliness to think that he could recover his sight when one of his eyes had not even a trace of the ball, but only the socket. As he slept a vision appeared to him. It seemed to him that the god prepared some drug, then, opening his eyelids, poured it into them. When day came he departed with the sight of both eyes restored.[16]

The remedies were conjured by the dreamers themselves. The dreamer had experience with his own complaint and perhaps had heard about the local treatment options that might be available. Then, it might be credible in some cases that a dreamed remedy already known was reapplied either by the priest or by another doctor and finally worked, at least a bit. Commonsense interventions not yet tried were also possible cures that might be a part of the dream.

Here is a cure that also gives a glimpse at the Greek attitude about the choice of a paramour:

> A man with a stone in his penis. He saw a dream. It seemed to him that he was lying with a fair boy and when he had a seminal discharge

> he ejected the stone and picked it up and walked out holding it in his hands.[17]

Some cures seem easier to explain because they may have been for somatoform disorders or otherwise-transient symptoms.

> A voiceless boy. He came as a suppliant to the Temple for his voice. When he had performed the preliminary sacrifices and fulfilled the usual rites, thereupon the temple servant who brings in the fire for the god, looking at the boy's father, demanded he should promise to bring within a year the thank-offering for the cure if he obtained that for which he had come. But the boy suddenly said, "I promise." His father was startled at this and asked him to repeat it. The boy repeated the words and after that became well.[18]

The inscriptions were not medical records and the exact details of the cases may have been exaggerated. The temple healers were paid for their practice either directly or otherwise. The degree of payment was variable, but there was probably an expectation of philanthropy at least.

> Euphanes, a boy of Epidaurus. Suffering from stone he slept in the temple. It seemed to him that the god stood by him and asked: "What will you give me if I cure you?" "Ten dice," he answered. The god laughed and said to him that he would cure him. When day came he walked out sound.[19]

But, the stingy were at risk:

> Hermon of Thasus. His blindness was cured by Asclepius. But, since afterwards he did not bring the thank-offerings, the god made him blind again. When he came back and slept again in the Temple, the god made him well.[20]

There were other benefits that the god could bestow along with improving symptoms of illness:

> Hagestratus with headaches. He suffered from insomnia on account of headaches. When he came to the Abaton he fell asleep and saw a dream. It seemed to him that the god cured him of his headaches and, making him stand up naked, taught him the lunge used in the pancratium. When day came he departed well, and not long afterwards he won in the pancratium at the Nemean games.[21]

The priests benefitted from the business of the temple healing and therefore promoted their cures as much as they could. Aristophanes, the comic playwright, described the incubation of his character Plutus (Wealth) for a cure of blindness, and the joke reveals that it was the priests who scarfed up the pastries left on the altar as tribute to the god.[22] The degree of commercial demand on the temple priests is not clear and may have been less in the Asclepiad temples than in the secular world, but there was a *quid pro quo* expectation. In cults associated with other healing deities, there was a more defined commercial aspect. The temple of Amphiaraus near Oropus provides a description of the standard healing practice for supplicants and the contract for getting it done:

> When someone comes to be healed by the god, he is to donate a first-fruit offering of at least nine obols of silver and deposit it in the treasury in the presence of the attendant. When present, the priest is to say prayers over the sacrifices and place the sacrificial animal on the altar; when he is absent, the one making the sacrifice is to do this. During the public sacrifice each person should say the prayers for himself, but the priest should say them over the public sacrifices and he should receive the skins of all the victims sacrificed within the sanctuary. Each person may offer whatever sacrifices he wishes. No portions of meat are to be carried out of the precinct. Sacrificers should donate the shoulder-portion of each victim to the priest

> except during a festival; at that time he should receive the shoulder-portion only from the public victims. Rules for incubation: the attendant should record the name and city of the person undergoing incubation when he deposits his money and display it on a notice-board for anyone to read. In the sanctuary men and women should lie separately, the men to the east of the altar, the women to the west.[23]

SECULAR MEDICINE

Even though the temples extolled their cures, the secular doctors as represented in *On the Sacred Disease* repudiated the divine intervention and the demonic origin of illness. They rejected magic as a valid treatment and relied on their own concepts of pathology, which of course were based on superficial observations and speculation with little biological validity. The efficacy of medicine in general was marginal, a fact that allowed the temple practice to resist whatever failure they had and stalled the bad publicity from the secular side. In fact, neither temple nor secular practice was very successful. *Epidemics* I and III document that 60% of the Hippocratic cases died. The doctors were savvy enough to teach that a good doctor knew when to refuse a case that was obviously hopeless; understanding the prognosis was important to keep a medical reputation intact.

Not every Hippocratic writer explicitly rejected supernatural influence in disease. The ancient Greek patients were probably not so polarized in their view of secular and temple medicine as the author of *On the Sacred Disease* wanted them to be, and as is the case today, most patients likely used prayers and incantations along with "medical" interventions. Patients moved seamlessly from the doctors' care to the temple for treatment as needed. The Hippocratic author of *Regimin* lists several remedies that can be used in diseases, and praying to the gods was one option. The author seemed to endorse at least a modicum of cooperation between the secular and the religious, at least in dream interpretation:

> Now such dreams as are divine, and foretell to cities or to private persons things evil or things good, I have interpreters in those who possess the art of dealing with such things. But all the physical symptoms foretold by the soul, excess, of surfeit or of depletion, of things natural, or change to unaccustomed things, these also the diviners interpret, sometimes with, sometimes without success. But in neither case do they know the cause, either of their success or of their failure. They recommend precautions to be taken to prevent harm, yet they give no instruction how to take precautions, but only recommend prayers to the gods. Prayer indeed is good, but while calling on the gods a man should himself lend a hand.[24]

There was perhaps less intellectual antagonism between religious and secular medicine than *On the Sacred Disease* portrays because neither excluded the other. Patients could be treated with a variety of methods—magical, herbal, religious as well as the secular—to ward off illness. Efficacy was limited in all of them, so none was absolutely dominant. The antipathy toward magical manipulation, demonology, and irrational behavior that was expressed in *On the Sacred Disease* still allowed the secular doctors to embrace Asclepius as their patron, as the origin of medicine itself, and as the icon of their competence. The reverence toward Asclepius was much deeper than the miracles that were documented in his temples. Galen called him "our ancestral god."[25]

On the Sacred Disease dismissed supernatural control of illness, as invoked by the temple doctors, and used a natural physiology of the body to explain and treat specific pathologic states. The author illustrated the rationalization of medical thinking that is the core contribution of the Hippocratic physicians. The erroneous physiological concepts of air and the pathology of phlegm as the cause of epilepsy do not annul the value of his rejection of magic and of his reliance on a natural basis for the clinical phenomena. His clinical observations of patients are also a testimony to the technical acumen of the ancient Greek doctors.

WHERE DID THE TEXT COME FROM?

The author of *On the Sacred Disease* was perhaps the same as the one who wrote *Airs, Waters, and Places* or a close disciple. The treatise is traditionally attributed to the school of Cos and dates from the latter part of the fifth century or likely around 400 BCE. The date can be estimated based on the physiology of the *pneuma*, which begins with Diogenes of Apollonia giving the text a *terminus post quem* of the last third of the fifth century. It is recorded in the list of Bacchius in the early third century, and it has traces of sophistic rhetoric that indicate a date prior to the fourth century.

On the Sacred Disease was probably committed to writing from a presentation to a general audience by a Hippocratic healer who wanted to attract patients away from the temple priests to his secular practice. He denounced the temple practice of medicine without denying the background divinity of illness and of the world as a whole. The Hippocratic doctors were commercial competitors of the temple practitioners for patients and reputation. The competition among secular medical practitioners for patients and their rivalry with religious healers demanded a vigorous effort to promote the methods they advocated as the best possible and to advertise their successes. The secular doctors acceded to the idea that the supernatural elements existed behind nature, but they dismissed divine intervention as an effective treatment of disease. The knowledge of natural phenomena, so they said, led to understanding the cause and management of diseases and health. The move away from the supernatural explanation of disease is one of the major unifying themes in the Hippocratic collection, and *On the Sacred Disease* is a prime example of the message.

The temple practitioners probably took up the secular methods that they could manage and added them to their dream treatments and other ritual activity they offered in the temples. Both the secular and the nonsecular healers did the best they could, side by side, to attract business and to help the patient. They both used herbal treatments that had been a part of healing since the Bronze Age and before. The Hippocratic doctors were

at odds intellectually with any magical intervention claimed as treatment but had a practical competitive motive as well.

The use of the sophist methods of persuasion were one force behind the polemical content seen in some of the Hippocratic medical texts. In her dissertation, Laskaris summarized the rhetorical influence on *On the Sacred Disease*:

> *On the Sacred Disease* engages in the debate, prevalent at the time in sophistic circles, concerning the definition of "*techne*." Viewed in this light, it is clear that the polemic against the magico-religious healers was not so much intended to rid medicine of irrationality, as to attract students and patients to the author by demonstrating the "technical" inferiority of his opponents' methods and explanations.[26]

NOTES

1. Laskaris, J., *The Art Is Long*, Brill, Leiden, the Netherlands, 2002, p. 59.
2. Temkin, O., *The Falling Sickness*, Johns Hopkins University Press, Baltimore, MD, 1971, p. 15; Robinson, T. M., *Heraclitus Fragments*, University of Toronto Press, Toronto, ON, 1991, frag. 46, p. 33.
3. Temkin, *Falling Sickness*, Herodotus III, 33: "He has been afflicted from birth with that grievous disease that some call sacred."
4. Jones, W. H. S., *Hippocrates I*, Harvard University Press, Cambridge, MA, 1923, p. 127
5. Edelstein, L., *Ancient Medicine*, Temkin, O., and Temkin, C. L., eds., Johns Hopkins University Press, Baltimore, MD, 1967, p. 246.
6. Edelstein, *Ancient Medicine*, p. 213.
7. The Christian Science church is the best accepted proponent of modern temple medicine, but other cults practice it. Almost all religious persons, when faced with serious illness, resort to prayer and supplication for relief. See Randi, James, *The Faith Healers*, Prometheus Books, Buffalo, NY, 1989, and Hines, Terrence, "Health and Nutrition Quackery," in *Pseudoscience and the Paranormal*, Prometheus Books, Buffalo, NY, 1988, pp. 253–276.
8. Edelstein, E. J., and Edelstein, L., *Asclepius*, 2 vol., Johns Hopkins University Press, Baltimore, MD 1945 (1998), p. 264. T459 = Inscription number (the inscriptions are numbered in the edition).
9. Edelstein and Edelstein, *Asclepius*, 1998, T436, p. 250.
10. Edelstein and Edelstein, *Asclepius*, 1998, T425, p. 239.
11. Randi, J., *Faith Healers*.

12. Edelstein and Edelstein, *Asclepius*, pp. 221–238.
13. Luck, Georg, *Arcana Mundi*, Johns Hopkins University Press, Baltimore, MD, 1985, pp. 141–144.
14. *Inscriptiones Graecae*, IV, 2nd ed., Frederic Hiller de Gaertrigen, Gualter de Gruyter und Socios, Berlin, Germany, 1929 (IG IV^2), 121–124; *Inscriptiones Graecae*, IV, Maximillian Fraenkel, ed., George Reimer, Berlin, Germany, 1902 (IG IV), 951–953.
15. Edelstein and Edelstein, *Asclepius*, T423(13), p. 232.
16. Edelstein and Edelstein, *Asclepius*, T423(9), p. 231 (modified translation).
17. Edelstein and Edelstein, *Asclepius*, T423(14), p. 232.
18. Edelstein and Edelstein, *Asclepius*, T423(5), p. 230.
19. Edelstein and Edelstein, *Asclepius*, T423(8).
20. Edelstein and Edelstein, *Asclepius*, T423(22).
21. Edelstein and Edelstein, *Asclepius*, T423(29).
22. Edelstein and Edelstein, *Asclepius*, T421. *Plutus*, 633–747.
23. Longrigg, J., *Greek Medicine From the Heroic to the Hellenistic Age*, Routledge, New York, 1998, p. 11; *Inscriptions Graecae,* VII.235. See also Edelstein, *Ancient Medicine*, note p. 149.
24. *Regimin,* IV 87, in Jouanna, J., *Hippocrates*, Johns Hopkins University Press, Baltimore, MD, 1999, p. 409.
25. Edelstein and Edelstein, *Asclepius*, T338.
26. Laskaris, *The Art*, p. 74.

4

On the Sacred Disease

Hippocrates

I (*L1*)[1]

This report concerns the disease called "sacred." It is my opinion that it is no more supernatural nor sacred than other diseases,[2] but it has its explanation in nature. Laymen, however, from their inexperience and utter amazement, consider a unique disorder like this to have a divine origin.[3] Men who are unable to understand this difficult disease support its divine origin but their approach is a shambles since they base their practice on simplistic methods of treatment using purification and incantations [10].

If a disease is considered divine because it is amazing then many diseases will be sacred, not just this one. As I will show there are other diseases that are no less amazing and portentous which no one calls sacred. For example, the fevers, Quotidians, Tertians, and the Quartans, by which they are not amazed, seem to me no less sacred or god sent than this disease. Moreover I see insane and delirious persons doing inappropriate things for no obvious reason [20]. I know that in their sleep many groan, shriek, gag, jump up, and even run out of the house. They are delirious until they awake, then although pale and weak, they are just as healthy and sane as before. This happens not once but repeatedly. There are many other different examples, and there would be much to say about each one.[4]

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Those who originally thought this disease was "sacred" seem to me to be similar to today's faith healers, magicians, charlatans, and quacks. These men claim to be very devout and to have deep knowledge. Then these men, cloaking themselves in piety and using the god to cover their incompetence, propose to help by offering something bogus. And so as not to appear obviously inept they name this malady "sacred" [10]. They also establish a remedy which is safe for their own reputation and using specious jargon they propose purifications and incantations. They also order the patient to avoid baths and the many foods which are unfit for a sick man to eat, including sea foods like red mullet, black tail, hammerfish, and eel since these are the fish most harmful. They advise against the meat from goats, deer, pigs and dogs since these are the meats most disturbing to the bowels. They ban poultry such as cock [20], pigeon, and bustard[5] and such fowl thought to be most indigestible. They forbid the mint, leek, and onion because the pungent vegetables do not agree with the ill. They preach against wearing black clothes because black is associated with death. They warn against lying on goatskin rugs or to wear goatskin and they say not to cross the feet nor the hands. All these things are done as a precaution against trouble. They make these rules based on a supernatural influence as though they have a special insight. They also cite other pretexts so that, if the outcome is a cure they would appear clever [30] but if the outcome is death, their excuses would protect them and they would hold to their pretense that it was not their fault, but the gods are to blame. They assume no blame since they did not give the patient medicines to eat or to drink nor did they soak him in baths.

I suppose[6] it follows that none of the Libyans living in the middle of their country could be healthy because they lie upon goatskins and eat the meat of goat, by necessity, since they have nothing, no blankets, clothes, or sandals which are not derived from the goat [40]. For there is no other livestock for them except sheep and goats. If eating or using goat products produces or worsens this illness and if avoiding goat products cures it, then a god is no longer the cause of it nor do purifications help; the foods

are healing and preventing the problem and the influence of the supernatural is removed.

III

In my opinion then, everyone who contrives to cure these diseases with the above approach is wrong to consider them to be sacred or supernatural. For what prevents these men, who can remove disease by such purifications and intervention, from using similar techniques in a different circumstance, to dominate men and attack them? Therefore the supernatural in no way would be the cause here, but there is something human. For whoever can abort such a malady by using [10] purifications and magic, being so skilled, could also *cause* other ones and for this reason the supernatural belief is destroyed. Such are the contentions and machinations by which they pretend to have special insight. They deceive their patients when they prescribe for them purifications and cleansing and the majority of their advice centers on the supernatural and divine intervention. Furthermore they seem to me indeed to make testimonies not about righteousness, as they purport, but rather about unrighteousness even as though the gods do not exist. Their piety and concept of the supernatural is impious and foolish, as I shall demonstrate.

IV

These men[7] who have such practices say that they can cause things to happen either by rituals or by some other cunning or method; if they claim to be able to bring down the moon, to eclipse the sun, to create winter storms or fair weather, to cause rain or drought, to make the sea rough and the land barren and to know how to do all sorts of such things then they seem to me to be extremely sacrilegious and they repudiate the gods and their power [10]. By making these claims how are they not odious to the gods? For if a man has magical power and by offering sacrifices will bring down the moon, eclipse the sun, and create winter storms or fair weather,

and if truly the supernatural power were overcome and dominated by the mind of a man, I would consider none of these things supernatural but under human control. Perhaps their claims are impossible. Men who need to make a living invent all sorts of things and embroider them into everything [they preach]. In this disease they also assign the cause for each form of the symptoms to a specific god [20]. For example if the person roars or makes goat-like noises or if the right side is contracted, they say that the mother of the gods is to blame. If a patient makes piercing and louder sounds, they equate him to a horse and say Poseidon is the blame. If one should pass some stool, which regularly occurs in the throes of the disease, the eponym Enodia is used. If there is more frequent, thinner stool, similar to a bird's, then the name of Apollo the shepherd is applied. If one froths at the mouth and kicks his feet, Ares takes the blame [30]. They say it is the attack of Hecate and the assault of heroes when, during the night, fear, terror and panic develop and the victim jumps out of bed and runs outside.

By using incantations and purifications, as I interpret it, they use unholy and godless practices. For example, they purify those gripped by this disease with blood and with other such rites reserved for someone who has had a pollution, or for an accursed miscreant, or someone bewitched by men, or for one who commits an unholy act [40]. But they should do the opposite for persons with this disease. They should pray for them and make sacrifice and carry them into the temple as supplicants to the gods. But they do none of these things, rather they purify them! What's more they bury some of the implements of purification, others they throw into the sea, and others they carry off to the mountains where no one will confront them or run across them. But if a god is in fact the cause, they should take them [the patients] to the temple and present them to the god. Moreover I do not think it is reasonable that the body of a man, extremely impure, is polluted by a god, extremely pure [50]. But even if one were defiled in some other way or suffered something else, he would be purified and cleansed by a god, rather than damaged by one. Certainly the powers of the gods provides to us purification sanctity and cleansing for our most vile and egregious sins, for us to purify ourselves. We ourselves establish the boundaries of the temples and of the sanctuaries of the

gods so that no one would cross over them unless worthy of blessing. When we enter, we sprinkle water on ourselves not as polluting ourselves but to drive out a previous pollution which we might have [60]. That's my opinion of purifications.

V (*L2*)

It is my opinion that nothing about this disease is more sacred than any of the rest but that it has a natural origin like the other diseases and there is an explanation behind each one. Likewise there is also a cure for this disease, and no less than for the other diseases, except when it becomes chronically entrenched so it is then resistant to the available remedies.

This disease has its origins as do other diseases in heredity. For if, from a phlegmatic parent is born a phlegmatic child and from the bilious a bilious child [10], from a consumptive, a consumptive child, and from a splenetic, a splenetic child then what prevents a mother or a father who carries this disease from affecting some of their children? Because the generative seed comes from all parts of the body, the healthy from the healthy parts and the diseased from the diseased parts.

There is however, a separate major proof that this disease is no more supernatural than the others: it occurs in those who are phlegmatic by nature but not in those who are bilious. And yet if it is more supernatural than the others, this disease must occur in all persons equally [20]. It would select neither the phlegmatic nor the bilious.

VI (*L3*)

But note, the cause of this malady is the brain as it is in other serious diseases. I will now explain clearly how it happens and its character.

The brain of man is double as in all other creatures, and a thin membrane separates the midline. That is the reason that pain does not always occur in the same part of the head but on one side or the other and

sometimes all over.[8] Numerous thin blood vessels also extend from the whole body to the brain but there are two which are large [10]: one from the liver and one from the spleen. The one from the liver has the following distribution: one branch called the hollow vessel [vena cava] extends down through the right side near the kidney and the psoas and goes into the inner thigh and down to the foot. The other branch extends upward through the diaphragm on the right side, through the lung where it also divides into the heart and into the right arm. A remaining branch carries on up through the shoulder girdle into the right side of the neck, into the skin on the same side so it is visible. Right beside the ear it goes deep where it branches. The largest branch in thickness and capacity ends in the brain. The other branches end in the right ear, in the right eye and in the nostril. That is the case for the vessels from the liver. There is also a vessel similar to the one from the liver that extends up and down from the spleen on the left side but it is thinner and less significant.

VII (*L4*)

We acquire the majority of the breath through these vessels for the vessels are the vents of the body; they draw in the air and convey it via the small vessels into the rest of the body where it is cooled and they send it back. The breath cannot stand still, but it moves up and down. For if it were to remain static and were hindered that area where there is stasis becomes weak. This is illustrated by the following fact: Whenever the small vessels have been compressed by lying [10] or sitting down on them, so that the breath can't move through them, the part compressed gets numb.[9] That's the situation with the vessels.

VIII (*L5*)

This illness occurs in the phlegmatic and not in the bilious. It begins to develop in the embryo when still in the mother. As in the other organs

the brain is also purged of impurities and develops Before birth. If in this catharsis the embryo is purged correctly and appropriately, with neither more nor less than the necessary substance flowing away, the result is a very healthy head. But if an excess should flow from the whole brain and there is a significant softening[10] [10], (the child) will have an abnormal head full of noise and will tolerate neither the sun nor the cold. But if an excess flows from a specific part either from the eye or the ear, or some vessel has been shriveled, that area where the softening has its effect is damaged. If however, there is no catharsis and fluid collects in the brain the infant as a rule is phlegmatic. In such infants sores break out on the head, ears, and skin; they drool and produce mucus [20] but later as he grows up, the child comes through these events most easily since in these cases the phlegm which should have been purged in the mother dissipates and flows out so for the most part such children so purged are not seized by this disease. However the ones who are clean and have no sores, mucus production, or drooling and have not undergone the catharsis in the mother, these are the ones that risk suffering from this disease.

IX (*L6*)

If the stream of phlegm makes its way to the heart, palpitation takes hold and there is shortness of breath. The thorax is damaged and some patients even become stooped. This is because the blood cools off when the cool phlegm enters the lungs and the heart. The forcefully cooled vessels throb against the lung and heart and the heart palpitates leading inevitably to breathlessness and orthopnea [10]. The patient does not obtain a satisfactory breath until the influx of phlegm having been warmed and controlled, dissipates into the vessels. Then the palpitation and the breathlessness stop, depending on the flow: if there is a lot of fluid production[11] the recovery is slower; if less, recovery is quicker. If the flow is more profuse there are more frequent seizures. So these are the problems which affect the patient should the [fluid] go to the heart and lungs. If it goes to the bowel, diarrhea occurs.

X (*L7*)

If, however, the flow of phlegm has been blocked from these pathways and it goes into the vessels going to the brain which I have described before, it will create a congestion [catarrh] and the person becomes speechless, and he gags. Froth flows from the mouth, the teeth are clenched, and the hands contracted. His eyes are deviated and he loses consciousness. In some cases there is incontinence of stool. I shall explain each of these symptoms.

Speechlessness occurs when the phlegm suddenly enters into the vessels [10]. Phlegm shuts out the air blocking it from the brain, the open vessels and the viscera. So it also interferes with the breathing. This is because when a man takes a breath through his mouth and nose, first it goes into the brain and then the major portion goes to the viscera, and some to the lungs and the vessels. It is dispersed from these sites into the remaining parts by the vessels. The breath that goes into the viscera [20] cools the viscera, and serves no other purpose. The air accumulates while going to the lungs, the vessels, viscera, and also the brain and thus it provides the sense and motion in the limbs. So whenever the vessels are occluded from the air by the phlegm and are not conducting, they cause speechlessness and unconsciousness in a man. Moreover the hands become weak and contracted because the blood has stagnated and is not dispersed normally [30]. The eyes deviate because the small vessels are deprived of the air and they throb. The froth flows out of the mouth from the lung, for when the lung has no breath it froths and boils up as occurs in a person about to die. The bowel incontinence follows the force of the gagging which is caused from the liver and upper bowel pressing against the diaphragm obstructing the outlet of the stomach. The patient falls down when the breath does not enter the mouth as usual and he kicks [40] with his feet when the air has been cut off in the limbs by the phlegm which is trapped there. The phlegm moves up and down through the blood causing spasms and anguish and that's why he kicks. The person suffers all these symptoms whenever the cold phlegm flows into the warm blood because the blood cools off and stagnates. Moreover if there is a lot of thick flow he dies right

away because the cold overpowers the blood and coagulates it. [50] With less quantity however, the phlegm prevails at the start, and interferes with the breathing. Then after a while the vessels disperse it and it's mixed with abundant warm blood. Whenever the warming process is successful, the vessels receive the air and the patient regains consciousness.

XI (*L8*)

Small children who become afflicted by this disease usually die if the fluid production is abundant and the wind is from the south. The reason is that the small vessels (of a child) being narrow are not able to conduct the phlegm because of its viscosity and quantity thus the blood cools off, coagulates and causes death. However if the flow is minimal and travels either in both of the vessels or into one or the other, he survives but has a deficit. The mouth droops and the eyes, [10] hand, or the neck is affected depending on where a small vessel, filled with phlegm, is overwhelmed and withered. Because of this {withered] minor vessel the part of the body which is damaged must have more disability and more weakness but as a general rule it is a benefit in the long run because the seizure does not recur once it makes its mark . Here is the reason: the rest of the vessels by necessity are disturbed and they shrink in some part so while they conduct the air, the flow of the phlegm no longer courses in them as it did [20]. Of course it follows that the limbs are weaker since the vessels are injured. In cases in which there is a north wind and a small flow completely to the right side, the patient survives unmarked. There is a risk of an exacerbation as the child grows unless he is treated with the proper remedies. That then is the situation for the children, or quite nearly so.

XII (*L9*)

Adults do not die when affected nor are they disfigured because their vessels are open and full of hot blood so that the phlegm is unable to

overwhelm the blood and coagulate it by cooling. Rather the phlegm itself is overwhelmed and mixed through with the blood quickly. Thus the vessels conduct the air and consciousness remains. The signs described above are less severe depending upon the person's state of health [10]. When, however, this disease occurs in the elderly it kills them or makes them crippled because their vessels are emptied and their blood is scant, thin and dilute. If a large flow occurs during the winter, the old man dies for the flow coursing on both sides blocks his respirations and clots his blood. If, however, the flow occurs only on one side it causes paralysis. The blood being thin, cold and sparse, is unable to prevail over the phlegm, but rather the blood itself is mastered and it coagulates so that on the side where the blood has been corrupted there is weakness.

XIII (*L10*)

The flow of phlegm is more into the right than into the left because the vessels are more opened up and numerous on the right. It flows and it melts mostly in young children in whom the head has been heated either by the sun or by a fire and then the brain cooled suddenly, for in this case the phlegm separates. First it is melted by the heat and the diaschisis in the brain and next it separates because of the cold and the accumulation flows down [10]. This is the cause in some cases, but in others whenever the south wind suddenly replaces the north wind, the change in wind dissolves and softens the brain which before was firm and healthy, so that the phlegm wells up thus producing the flow. In addition the flow occurs from being startled so it occurs if [a child] should be scared by a shout or is not able to catch his breath quick enough between crying spells: things which repeatedly happen to children. Whichever is the case, the body cools right away [20], and the child unable to get a breath becomes speechless and his breathing is shallow. The brain solidifies and the blood stands still; consequently the phlegm separates off and it flows down. Such are the causes of epilepsy for children at the beginning.[12]

But [25] for the elderly winter is the biggest threat. For whenever his head and the brain are overheated by a hot fire and then he happens to go into the cold and shakes with a chill, or even if he comes in from the cold into the warmth beside a big fire, he suffers the same changes as described above and a seizure occurs [30]. There is a significant risk to suffer the same thing in the spring when the head has been exposed to the sun. The risk is least in the summer because the temperature changes are not sudden.

After the age of 20 the disease itself no longer attacks, unless it was established in [35] childhood and then the seizures are few or don't occur. The reason is that the vessels are abundantly full of blood and the brain is solid and is firm so that phlegm does not flow down into the vessels. If it should flow down it does not overcome the blood, which is abundant and warm.

XIV (*L11*)

When the disease has grown and developed from early childhood a pattern is established so that they suffer during changes in the winds, and a seizure occurs then in many cases and especially with a south wind. Recovery comes with difficulty for the brain has become more moist than normal and is flooded with the phlegm. As a result the flow is more frequent, and the phlegm is not able to separate out, nor is the brain able to dry up [10]; but rather it remains saturated and is wet. One might best understand this point by understanding the livestock which are attacked by a disease like this, especially when it happens in the goat since that's the animal attacked most frequently. If you cut open the head, you will discover that the brain is moist, quite edematous, and foul smelling. By this observation you will understand quite clearly that it is not a god afflicting the body but a disease. It also holds true for a man.

When the disease becomes chronic it is no longer curable because the brain [20], damaged by the phlegm, is also softened; the softened part becomes liquid and surrounds the brain externally and floods it. On

account of this seizures occur more frequently and more easily. So it follows that the disease becomes chronic because the surrounding fluid is dilute, and is quickly overwhelmed by the blood and warmed.

XV (*L12*)

The ones who are accustomed to the disease will know when they are about to have an attack and they withdraw from the company of men. If home is near, they go home, if not, then to the most secluded place, where the fewest are likely to see them falling. The victim immediately hides his head not because of fear of a spirit, as most laymen think, but he does this from shame of the malady.

Young children lacking experience fall at first wherever they are at the time. However after repeated attacks whenever they experience the prodrome they run to their mothers or to whomever they know best. They flee because of fear and terror of the malady since they don't yet know what it is to be ashamed.

XVI (*L13*)

Based on the ideas presented I say that seizures occur from shifting of the winds and chiefly from the south winds, then from the north winds, then from the rest of the winds. The north and south winds are much more powerful than the rest of the winds and the most opposed to one another based upon their direction and their power.

The north wind condenses the air, separates out the turbidity and moisture, and also creates clarity and transparency. According to the same character it also does the same to everything originating from the sea and the other waters [10]. It separates the moist and the turbid from everything, including man himself, so it is the most healthy of the winds. The south wind, however, acts oppositely to the north wind. First it begins to melt down the condensed air and disperses it. Also it does not blow strong

at first but is calm, because it cannot immediately overpower the air which in the beginning is both thick and condensed, but over time it disperses it [20]. This same process affects the land, sea, rivers, streams, wells, and also the things that grow in which there is some water. Of course water is in everything and all things feel the effect of this wind more in some less in others and change from clear to murky, from cold to hot, and from dry to wet. Jars of wine or other fluid either in storerooms or under the ground all sense the south wind and alter their condition and appearance [30]. The south wind causes the sun and the moon and the other stars to be a lot dimmer than is normal. Since it overpowers such great and potent things in this way, the body also senses it and changes with the influence of these winds. As a rule the south wind loosens and moistens the brain and the vessels dilate. The north wind, however, concentrates the most healthy aspects of the brain. It separates out the most diseased and moist aspects [40] and cleans them out and thus the flow develops from the changes in these winds.

Therefore this disease itself is born and develops from things entering and leaving the body; there is nothing more obscure about it than in other diseases neither in treating it nor in understanding it. It is no more divine than the others.

XVII (*L14*)

Mankind must realize that there is but a single organ from which come our pleasures, joys, laughter and wit. From that organ also comes our sorrow, grief, anxiety and lamentation. The brain is in fact that organ; from it comes our intellect, and our vision, and our hearing. Through it we judge the ugly and the beautiful, the noble and the ignoble, the pleasant and the unpleasant making our choice partly by our conventions and partly by what we perceive as useful. And it is from the brain that we become mad and delirious. Fear and terror [10] accost us at night and also in daytime. Abnormal sleep, troublesome inattention, unfounded concerns, and the neglect of traditional practice and naïvete haunt us. We suffer all of these

things whenever the brain is not healthy but is heated or is cooled more than normal or is more moist or dry; also when it has suffered some other situation outside the norm to which it is accustomed. We are driven mad by the excess wetness for whenever there is more moisture than normal, the brain must shift but when it moves the vision and the hearing are activated and we see and hear one thing and then another, and during the episode the tongue speaks things as they appear. The patient comes to his senses when the brain calms down.

XVIII (*L15*)

Damage to the brain occurs from both phlegm and bile. You will know the difference by the following signs. Patients who become mad from phlegm are quiet and are neither loud nor rowdy, whereas those who are affected from bile are screamers, restless, troublemakers, and repeatedly doing something inappropriate. If the madness continues, those are the causes. However, if terror and fears set in there is a shift in the brain: [10] it is altered by being heated, and it is heated whenever bile surges into it from the body through the blood vessels. The fear stays until the bile goes back into the vessels and to the body, then it ceases. But the patient is distressed and anguished unduly after the brain has been cooled and contracted inordinately. He suffers this from the phlegm and its effect also makes him forgetful. The patient screams during the night with a shout whenever the brain is suddenly overheated; [20] the bilious suffer this but not the phlegmatic.

The brain also warms whenever a lot of blood enters into it and it seethes. The blood comes mainly from the vessels mentioned above whenever a man happens to see a nightmare and is frightened. Just like when a man who is awake is frightened or his mind contemplates something evil his face becomes flushed and his eyes redden; the same thing happens during sleep [30]. Then on awakening when he collects his thoughts and the blood disperses back into the vessels, it's over.

XIX (*L16*)

Based on the foregoing concepts I believe that the brain is the most powerful organ in man. If it is healthy, it interprets for us the actions of the air, and it is the air which allows cognition. The eyes, the ears, the tongue, the hands and the feet accomplish the things which the brain conceives for the brain controls cognition in the whole body as it shares the air. The brain is the one organ that informs the consciousness [10]. For whenever a man draws his breath, it travels first to the brain, and, after it sets down its own essence in the brain and whatever it may have of intelligence and knowledge, from there the air disperses into the rest of the body. The air would lose its perfect value if it went to the body first and later to the brain, having spent its discerning power in the flesh and the vessels and coming, mixed with the fluids from the flesh and the blood, warmed and impure into the brain.

XX

Based on the arguments so far I say that the brain is the interpreter of consciousness. The diaphragm has that name erroneously through chance and common usage but not by its actual nature. I am not aware that the diaphragm has any ability to think and to reason. Granted if a man is overcome with either grief or joy, the diaphragm jumps and produces a jerk since it is so thin and because it has been stretched the most in the body. Moreover it has no cavity which [10] is needed to receive either a good or bad incident and because of its feeble nature it responds to either type of event. Since the diaphragm is never first to appreciate any of the phenomena in the body, it has this name and reputation arbitrarily. Similarly there is a part of the heart called the "ears" although it has nothing to do with hearing. Likewise it is said that we think with our heart and it is the organ of distress and anxiety. But this is not the case although the heart does jump just like the diaphragm and more so for

the following reasons [20]. The vessels from the whole body extend into the heart; it encloses them so that it senses if any pain or tension occurs to the person. Moreover it is a fact that if a man is anxious he trembles and tenses up; the same thing happens when he is overjoyed. That follows because the heart and the diaphragm sense things very well but indeed there is no aspect of cognition in either one. The brain causes all these actions; it is the first part of the body to perceive the intelligence [30] of the air, therefore if there is a severe change in the air because of the season the brain itself becomes different.

That is why I say that the diseases that attack the brain are the most harsh, the most severe, the most lethal and are the most difficult for the inexperienced to fathom.

XXI (*L18*)

This disease, called sacred, arises from the same causes as in the rest, from things coming and going in the body, from the cold and the sun, and from the changing winds that are never calm. These things are divine so there is no need to separate this disease and consider it more holy than the rest. All of the diseases are sacred and all human. Each one has a nature and a potential of its own and none is impenetrable nor unmanageable [10]. Most are curable by the same things by which they are caused. For a specific food is suitable in one case, another in another, and in fact either one may be injurious at times. This is a paradox which the physician must understand so he discerns the season of each action: at one time he will provide nourishment for growth, but at another time he removes it as injurious. For one must not foster growth in this disease nor in all the others, but wear it down by bringing upon each disorder the most noxious things and withholding things to which it is accustomed [20]. A disease is activated and grows in its customary environment but withers on hostile ground and even stops. Whoever manages a man's lifestyle to influence in him the dry and the wet, and the cold and the warm, and if he discerns

the seasons for beneficial treatments, he also would be the one to cure this disease, without resorting to purification and magic [26].

NOTES

1. The sections marked *L* indicate the work of E. Littre, *Oeuvres Completes D' Hippocrate*, vol. 6, Hakkert, Editeur-Amsterdam, Amsterdam, the Netherlands, 1962 (reprint of the 1849 edition). Roman numerals mark sections in the Jones edition. Numbers in square brackets indicate line numbers. Jones, W. H. S., *Hippocrates* II, Harvard University Press, Cambridge, MA, 1923.
2. Jones, *Hippocrates II*, vol. I. *Airs, Waters, and Places* expresses this idea at XXII.8–10; there are numerous parallels between the two works.
3. The initial lines in the manuscripts are corrupt, and there are as many readings as editors. This is Jones's reading.
4. I take this to mean "ample evidence" rather than "so much to say that I won't take the time."
5. These are large birds that prefer to remain on the ground. We do not eat bustard, so one might envision a turkey.
6. The subjunctive adds a bit of the supposition to *dokeo*. This an early example of the developing Greek logic (the modus tollens argument: If A then B, but not B, therefore not A), later defined by Aristotle and then the Stoics. See Lloyd, G. E. R., *Magic, Reason, and Experience*, Cambridge University Press, Cambridge, UK, 1979, p. 25. The author does not quite use the logic in his refutation in that he jumps to the next level by saying that if identifiable things are at fault, then it is not the divine.
7. Empedocles was reputed to be able to control the winds and to avert plague by changing the winds. The practitioners took names like "wind repeller" and the like. See Empedocles, frag. 15/111 and testimonia A13 for examples. Inwood, B., *Empedocles*, University of Toronto Press, Toronto, ON, 1992, pp. 211 and 156.
8. This is like a migraine headache.
9. The term *narke* was used as a name for an electric eel, so it includes numbness and electric tingling. This is a description of compression neuropathy. Patients even now believe the phenomenon is from lack of "circulation." Elsewhere in the *Corpus*, the term is used more generally as when the whole body becomes numb or the whole head.
10. *Apoteko* means melting like snow or wasting. The concept seems to be that the brain is a solid object that undergoes transformation by dissolving to produce fluid (cerebrospinal fluid?). The concept of brain melting is preserved in later thinking, and cerebral lesions were known as softening; encephalomalacia is still used as a general description of a loss of brain tissue. See Gowers, W. R., *Diseases of the Nervous System*, Blakiston, Philadelphia, PA, 1888, p. 807ff., for example.

11. The terms *epikatare*o ("flow on down") and *katarrooi* ("down flow") are not modern ideas as used here; "fluxation" has been used, but it seems reasonable to render "secretion," which is general enough to include the flow of liquid, which is the implication.
12. The only use of *epileptos* in the treatise.

5

Head Injury

Wounds of the Head is a short surgical text written by an experienced physician as a guide to the diagnosis and treatment of head injury. The treatise was written for physicians to use in their practice as a technical book, so it reads like a package insert for a product. It shows the degree of precision that the surgeons had in understanding the superficial anatomy of skull injury but does not make other associations with trauma. The author had little to say about the injury to the brain itself but was detailed about the evaluation and treatment of the bone injuries that he could easily see in his patients. Many of the skull injuries that he described were from a severe impact to the head, and many had avulsion of the scalp. The Greeks had no guns, and violence, among violent people, was delivered by knife, stone, arrow, or spear. The head injuries described in the *Iliad* attest to the ferocity of trauma that the physician might have confronted.

The opening of the treatise describes the position of the sutures of the skull, but it is not particularly accurate by anatomical standards. The sutures of the skull could obscure the mark made by the weapon, the *hedra,* so they were important in diagnosing the extent of the trauma. One guesses that the description of the sutures was based more on speculation than observation because there was not much opportunity to observe human skulls at this point in Greek medicine. The surgical procedures are, however, obviously based on experience and observation.

The author used specific technical words for the type of injury to the bone, and there are many Greek terms used that are defined by their use in this treatise. The untranslatable term *hedra* (in another context, it means "seat") is a technical term for any cleft in the bone caused by the cutting edge of the weapon that incises or scratches, but does not displace, the bone. Crush injury to the bone was Hanson's choice of a term for a bone contusion, but I have continued to use the word *contusion* because now we do recognize bruise to the bone itself. Displaced fractures and comminuted fractures are also indicated with specific terms. Surgical treatment of the physical lesion to bone was specifically discussed, but the medical treatment was merely mentioned in passing as "do what it seems is right." The author described the suppuration and necrosis of the fleshy part of the wound, which helps direct the surgical debridement, but it was mentioned briefly with few details.

To treat the skull injury, the surgeon exposes the bone under the scalp wound, determines the type lesion that appears in the bone, and then decides if decompression with a burr hole is needed. The surgeon can examine the bone with a few instruments by scraping, probing, or inspecting directly by eye. Treatment decisions are dictated by the character of the wound and the degree of bone damage.

The term *trephine* is not heard much today, so I have opted to use "burr hole" or "sawing" to render words for that procedure. The trephine was an instrument that made a circular hole in the skull. It was run by twisting by hand or by a rope wrapped around the vertical stem attached to the blade and pulled to rotate the saw. There was also a drill with a narrow bit that did not remove a disc of bone. Other surgical activity, unless specified in the text, was just rendered as an "operation" because we do not really know what the exact procedures were.

The definitive text, translation, and commentary, published in 1999, were done by Maury Hanson.[1] Hanson is a neurosurgeon, so his medical insight was helpful in rendering and explaining the text. He was exact in following the Greek syntax and establishing the vocabulary for the injuries described. I have consulted his translation and text in this translation. I have also consulted the translation and text from the Loeb edition

by E. T. Withington to check my translation.[2] *Wounds of the Head* dates from the fourth century; the latest possible date is about 336 according to Hanson.

Galen knew this text, but only a fragment of his comment is extant. The surgical treatment described in *Wounds of the Head* also appears in *Epidemics* V, which is a later text in the *Corpus Hippocraticum*. The following three cases of head injury are from *Epidemics* V[3]:

> Case 16: Hippocomus son of Palamedes in Larissa, eleven years old, was struck on the forehead above the right eye by a horse. The bone did not seem sound and a little blood spurted out of it. He was trephined extensively down to the diploe. And he was cured, despite this condition of the bone, which before was readily festering. On the twentieth day a swelling began by the ear, and fever and shivering. And in the day time the swelling and pain were greater. He became fevered, beginning with shivering. His eyes swelled, and his face. He was affected more on the right than the left of the head, but the swelling spread also to the left. That did no harm. Finally the fever was less continuous. These things continued until the eighth day. He survived, after being cauterized, purging it with medicine for drinking, and treated with plasters on the swelling. The wound was not responsible for his problems.
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> Case 27: Autonomus in Omilus died on the sixteenth day from a head wound in midsummer. The stone, thrown by hand, hit him on the sutures in the middle of the bregma (front of head). I was unaware that I should trephine, because I did not notice that the sutures had the injury of the weapon right on them, since it became obvious only later. First he had sharp pain towards the collarbone, later in the sides, and convulsions into both arms, for he had the wound in the middle of the head and the bregma. He was trephined on the fifteenth day and some pus came out. But the membrane appeared uncorrupted.
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> Case 28: At Omilus, a young girl of about twelve years died in midsummer from a wound in the head, on the fourteenth day. Someone hit her with a door and crushed and shattered her skull. The sutures

were in the wound. This was recognized properly as needing trephination. It was trephined, but not sufficiently. As some bone was left, pus developed there. On the eighth day shivering and fever seized her. When free from fever she was not as she should have been, but was as on the previous days. On the ninth day the rest was trephined, and a little pus with blood appeared. The membrane was clean. Sleep seized her, but the fever did not go away again. Spasms seized her left hand, since the wound was on the right.

NOTES

1. Hanson, M., *De Capitus Vulneribus*, CMG 14.1, Academic Verlag, Berlin, Germany, 1999.
2. Withington, E. T., *Hippocrates* III, Harvard University Press, Cambridge, MA, 1928, pp. 1–52.
3. Smith, W., *Epidemics* V, *Hippocrates* VII, Harvard University Press, Cambridge, MA, 1994.

6

On Wounds of the Head

Hippocrates

I

The heads of men are different from one another and the sutures of the head have not developed the same ways in all men. In the case of one who has a prominence (a round projection of bone standing out from the rest of the bone) in the front of the head, the sutures develop in the head as the letter T is written. For there is a shorter line that develops crosswise above the prominence and the other longer line develops through the middle of the head lengthwise, going all the way to the neck (11). One who has a prominence at the back of the head develops the sutures the opposite way, rather than as in the previous case, for the shorter line develops crosswise before the prominence, and the longer line develops through the middle of the head lengthwise going all the way to the brow. For one who has prominences on both ends of the head, in front and in back, in this case the sutures develop in the same way as the letter H is written (20). The long lines develop crosswise at each prominence and a short line develops lengthwise through the middle of the head ending at each long line. In one who has no prominence on either end, the sutures of the head develop as the letter X is written. The lines develop so that one goes crosswise to the temple the other lengthwise through the middle of the head.

(30) The bone is double along the midline of the head. The hardest and the densest parts have developed at the very top layer where the smooth part of the bone is under the skin, and at the very bottom layer where there is also a smooth part of the bone next to the dura. The bone tissue passing between the top bone layer and the bottom bone layer, the hardest and densest bones, becomes softer, less dense, and more porous forming the diploic bone. The diploic bone is the most porous, softest and is especially filled with spaces (40). All the bone of the head is really similar to a sponge except for the little on the very top and very bottom. The bone has a lot of spongy flesh within it and it is moist so if one rubs it with the fingers blood flows from it. There are also comparatively small and hollow vessels full of blood in the bone. So that summarizes the hardness, softness and porosity.

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Now about the thinness and thickness: the bone in the region of the anterior skull is thinnest and weakest of the entire head, and the scalp is thinnest and least abundant in this same part of the skull. The greatest portion of the brain lies under this part of the head as well. Indeed because of these factors, the bone in this part of the head is crushed, fractured, and staved in more than most other parts of the head after trauma (10) when the weapons and wounds are the same or even less, and the victim is wounded the same or even less severely. Also a wound in this part of the head as opposed to anywhere else in the head is the most lethal and the most difficult to treat medically to prevent death. Moreover when the injuries are similar and when the wounds are equal or even less, a man dies quicker when he has an injury in this part of the head rather than in some other part when the trauma happens to be lethal (20). The brain is quickly and severely injured from a malady affecting the scalp and bone in the anterior skull for the brain is under the thinnest bone and the least scalp here and the largest part of the brain lies beneath the anterior skull.

The bone along the temples is the weakest among the others because it has the junction of the lower jaw at the skull and there is movement at the temple up and down as in a joint. In addition the organ of hearing is near the same place and there is a vessel, hollow and prominent, stretched through the temple (30).

The bone of the head is altogether stronger behind the vertex and the ears than anywhere at all in front and this (posterior) bone has a thicker more abundant scalp on it. Based on these facts, the bone will be fractured less and staved in less in this part of the head when the wounds and weapons are the same type, and similar, or worse in degree and the victim is injured equally or even more so. Moreover if the man is bound to die in any case from the trauma, he dies more slowly when he has the injury in the posterior part of the head (41) because it takes a longer time for the skull to suppurate down to the brain in and through the greater thickness of the bone. In addition there is less brain underlying this part of the head. As a rule more of those who are injured in the posterior part of the head escape from death than those injured anteriorly. And for head trauma at any site, when he's bound to die from the wound, a man lives longer in the winter than in the summer.

III

The *Hedras* (defects in the bone) caused by sharp, light weapons occur in both anterior and posterior parts of the head by themselves in the bone without a fracture, contusion or depressed fracture-contusion. These injuries as a rule are not the cause of death, even when death occurs. When a suture appears in the wound where the bone has been stripped, whereever on the head the wound has occurred, and if the weapon happens to stick into the suture itself, the bone is too fragile to withstand the weapon (10) and the injury, and most of all when the weapon happens to hit the weakest part of the head, the anterior part, if the sutures happen to be near the wound, and the weapon happens to hit the sutures themselves (15).

IV

There are a number of types of skull wounds and for each type wound there are many forms of damage that occur in the wounding. The bone is fractured when wounded and along with the fracture, the injury is necessarily complicated by contusion in the bones surrounding the fracture site, if there really is a fracture. For the same part of the weapon which really fractures the bone, crushes the bone more or less both in the same place where it splits the fracture and also in the bones surrounding the fracture (10). This is one type injury. There are many forms of fracture: there are the very slight and even tiny forms that are not obvious at the onset of injury or in the days during which there would be possible help for the suffering in the man at risk of death (15). Again some forms of fracture are larger or wider and some are even huge. Among these wound types some are longer and some shorter, some are mostly straight and some completely straight, some are rather curved and some bent, some go fairly deep down and some go through the bone completely (23).

V

The bone may be crushed and remain in its original place without any fracture in the bone complicating the contusion. This is the second type and there are many forms of contusion. For the contusions may be more or less severe, deeper, and even going through the whole of the bone, or less deep and not going through the whole bone and they may vary in length and width (10). But none of these forms can be recognized by eye, not the shape or the extent. For it is not possible to know clearly by observation immediately after the trauma if there has been a contusion, even when contusions exist and there has been harm done, just as it is not clear when there are some fractures at a distance from where the bone has broken.

VI

The bone is crushed inward from its natural position with fractures, otherwise it would not be a depressed contusion. For the bone that has a depressed contusion is broken, shattered, and crushed inward away from the other bone which remains in its natural position. And of course the fracture would be complicated by a depressed contusion. So this is the third type and the depressed contusion has many forms that involve more of the bone or less of it and are deeply depressed or quite shallow.

VII

And when a weapon causes a *Hedra* (a defect) in the bone, a fracture may complicate the *Hedra*. And if a fracture really occurs there, a contusion would also necessarily be a complication more or less severe, and also in the bone surrounding the *Hedra* and fracture. This is the fourth type. The *Hedra* might also have a contusion of the bone around it but there would not be a fracture complicating the *Hedra* and contusion caused by the weapon. [This is the fifth type.] (10) And the *Hedra* from a weapon occurs in the bone and it is called "*Hedra*" when the bone remains in its natural position after the weapon has stuck into the bone and it clearly marks the place where it had stuck. This is the sixth type (14). Within each type many forms occur regarding both contusions and fractures. If both these complicate the *Hedra*, or if contusion occurs alone, it has already been described that there are many forms of contusion and fractures. The *Hedra* itself may occur on its own being longer or shorter (20), more curved, straighter or circular. There are also many other forms of these types depending on the point of the weapon that might have been used. The *Hedra* itself may be more or less deeper and more or less narrow or wider and gaping where there is an open cleft (25). A cleft of whatever length or width in the bone is a *Hedra* if the other bones surrounding the cleft remain in their own natural position and within the cleft there is no

associated fracture depressed from its natural position. In which case it would be a depressed fracture, no longer a *Hedra*.

VIII

The bone may be injured in a part of the head other than the place which the man has the lesion and where the bone is stripped of the flesh. This is the seventh type and whenever this occurs there is no way to help in any way. For if a man has suffered this dire event, in that case it is not possible to know by examining him if he has suffered this malady nor to know where it is in the head.

IX

Among these types of bone injury, the contusion, either the type which is not obvious or the one detected in some way, or the fracture, either the type which is not seen or which is obvious, both get a burr hole. A patient gets a burr hole also if there is a *Hedra* from a weapon in the bone and a fracture contusion complicates the *Hedra*, and also if a contusion alone without fracture complicates the *Hedra*. However when the bone has a fracture depressed from its natural position only a few of the cases need a burr hole. Moreover the contusions pushed in the most and the ones most shattered are least likely to need a burr hole. A *Hedra* occurring by itself without a contusion or fracture does not need a burr hole, not even if the cleft is big and wide, not in this case because the cleft and the *Hedra* are the same thing.

X

First it is necessary to examine the wounded man where the head trauma has occurred either in the stronger or the weaker part of the skull.

Examine the hairs which are around the wound carefully to determine if they have been cut through by the weapon and if hair went into the wound. If this is the case one must say that there is a risk that the bone is stripped of flesh and there is some lesion in the bone from the weapon. You need to say these things while examining the victim from a distance not having touched the man (10). Once you touch him, attempt to recognize if the bone is stripped of the flesh or not. If the bone is clearly visible to the eyes, it is exposed but if not, examine it with a probe. If you discover that the bone is bare of flesh and is not intact from the trauma, you must first determine what happened to the bone by observing how much damage there is and determine what procedure is needed. One must also ask the trauma victim how he suffered the injury and what sort it was. If the bone is not clearly seen to have something wrong or not (20), it is even more important than when the bone is exposed, that you make inquiry about how the trauma happened and what sort it was. For when the contusions and fractures are not obvious in the bone, but are there, one must attempt first to determine from the victims report if the bone suffered or did not suffer one of these injuries. Figure it out then from reasoning and examination. Resist the probing for one does not figure out if the bone has suffered any of these maladies with the probe, or what happened to it, or if it suffered nothing (30). But using the probe does pick out the *Hedra* from a weapon and if the bone has a fracture depressed from its natural position, and if the bone is broken severely; the very things are detected that are also obvious by the eye.

XI

The bone is fractured having obvious or inobvious injury, is contused with an inobvious crush injury or may have a fracture depressed from the natural position, and is more likely when one person has been wounded deliberately by another person with premeditation rather than by accident. This is also the case when the strike or the blow, whatever it may be, occurs from higher up rather than when it is from a level place. It is more likely

also if the weapon is handled skillfully either thrown or struck as well as when a stronger person wounds a weaker one (10). In the case of someone who wounds himself around the skull or on the skull itself by falling from an extreme height onto someplace very hard and blunt he is at danger to fracture the skull, to contuse it, and to sustain a contusion depressed from the natural position (15). In the case in which someone falls while on fairly level ground onto someplace very soft, the skull is less likely to suffer these things or suffers not at all. Among those weapons which are targeted at the head, the one which hits from higher up rather than from level ground, and at the same time is the hardest rather than softest, bluntest rather than sharpest, and heaviest rather than lightest, will fracture the bone and crush it (25). There is also special danger indeed that the bone suffer these injuries when the things mentioned above happen and when the skull is wounded straight-on either by a blow by hand or by a missile and the weapon hits perpendicular to the bone or when the bone is hit directly either by something falling on the man or if he is injured by falling down himself, or from being wounded in any way in which the bone is hit directly by the weapon (31). Weapons that glance off the skull sideways fracture the bone less and there is less contusion and depressed contusion even if the bone is denuded of flesh. For sometimes the bone is not stripped of flesh when the wound is inflicted in this way (36). Rounded, smooth, blunt, heavy and hard weapons especially fracture the bone and cause obvious and inobvious fractures, contusion and displacement in the bone from the natural position (41). These weapons contuse the flesh and crush it into pulp. Injuries caused by these weapons have margins that become undermined on one side or all around and are likely to suppurate. They are moist and take a long time to clean up for the contused and macerated flesh must dissolve by turning to pus.

The flesh and similarly the bone as a rule is cut through rather than crushed by the elongated weapons which are thin, sharp and light weight (51). The weapon makes the *Hedra* or cleft since *Hedra* and cleft are the same thing. But such weapons do not readily crush the bone nor do they fracture nor displace the bone from the natural position (54). In addition to what you see revealed to your own eyes in the bone you also need to

make inquiry about all these issues. Ask if the victim was knocked out or blacked out, if he began to have vertigo and fell down, for these are the signs of the severity of the trauma.

XII

When the skull happens to have been stripped of flesh by a weapon and the wound happens to be along the sutures themselves, there is a difficulty even to identify the presence or absence of the *Hedra* from the weapon in the bone, a *Hedra* which would be obvious in another part of the bone, is not obvious if the *Hedra* happens to occur in the sutures themselves. For the suture itself being quite rough compared to the other bone is misleading so that the part which is the suture and that part which is the *Hedra* from the weapon is not distinguishable (10) if the *Hedra* is not extremely large. In most cases when a fracture occurs in the sutures it complicates the *Hedra* and when that happens the fracture itself becomes very difficult to detect even though the bone has fractured. Here is the reason: If there is a fracture, the fracture usually occurs along the suture itself, for the bone in this place is likely to fracture and the suture becomes separated on account of the natural weakness of the bone in this place and on account of its porousness. Moreover the suture is likely to fracture and become disjointed (20) while the other bones surrounding the suture being stronger than the suture remain unbroken. When a fracture occurs along a suture and there is separation of the suture, it is not easy to see when it fractures and separates, neither if it is from a *Hedra* of a weapon which occurs in the suture, nor if it is fractured and separated when the skull is contused along the suture. But it is quite difficult to discern the fracture from the contusion. For the sutures themselves which mislead the eye and evaluation of the physician (30), look like fractures, since they are much rougher than the other bone when they are not terribly gashed and separated. The cleft and the *Hedra* are the same. But if the trauma occurs along the suture and indeed to the bone and the weapon sticks into the bone, one must pay attention to detect what the bone has suffered

(36). The weapons being equal in size, and even much smaller, similar in type more or less, and wounds being similar and even much less so, the wounded man acquires much greater harm in the bone if he takes the weapon's hit in the suture rather than if he does not take it in the suture. And the majority of these cases require a burr hole but one must not operate on the sutures themselves but move away if you choose to drill and make the burr hole in the adjacent bone.

XIII

Here is my opinion concerning the management of head wounds and what must be done to figure out the lesion which occurs in the bone when it is not obvious. There is no need at all to moisten a soft tissue wound in the head, not even with wine or with very little of anything else. One must not apply a plaster or provide a packing. It is not indicated to bandage a soft tissue wound in the head if the wound is not on the forehead, around the brow or eyes, or in a place bare of hairs. Wounds that occur in these places usually require plasters and bandages more than elsewhere in the rest of the head (10). For the rest of the head completely surrounds the brow and the soft tissue wounds, wherever the wounds may be, so they fester and swell on account of the influx of blood from the surrounding parts (15). One need not plaster and bandage the injuries even on the brow for the whole time but whenever the wounds stop weeping and the swelling subsides, discontinue the plaster and the bandages. Also one need not pack a wound in the other parts of the head nor plaster or bandage it, if it does not require an incision (20).

One must incise soft tissue wounds occurring in the forehead and in the head whenever the bone is stripped of the flesh and you suspect that there is some injury from the weapon. Incise also when the soft tissue wounds are not large enough in length and breadth to expose the bone to see if it suffered any harm from the weapon and what degree it suffered, in addition to see the extent that the flesh has been contused and to see what injury has come to the bone or alternatively to see if there is no bone

injury from the weapon (30) and no harm was suffered. It is also necessary to see what sort remedy the case requires for the wound, both for the flesh wound and for the condition of the bone.

These kinds of wounds require incision: When the bone has been stripped of the flesh and there is an extensive undermining into the side, in such cases one must cut open the cavity further wherever it is not easy for the necessary medicine to get to. You should also make the more circular and extensively undermined soft tissue wounds and wounds such as these longer by double cutting the circle vertically, as the patient has grown (i.e. on the vertical axis) (40).

In regard to making an incision on the head, there are some parts of the head that are safe for surgery, but the temple and the area above the temple, where there is a vessel running down along the temple, is not a place to incise; for a spasm seizes the patient who is operated there. If one cuts the temple on the left side, spasm seizes the parts on the right and if the right temple is cut, spasm seizes the parts on the left.

XIV

Therefore when the bone has been separated from the flesh and you want to see if a weapon has caused some harm or not, you must incise the wound in the head and make the incision large enough to be sufficient. While making the incision you must raise the flesh off the bone where the bone and membranes have grown together. Then pack the whole wound with "packing lint" such that it will produce the broadest incision on the next day with the least pain (10). After packing apply a plaster, for the same time as the packing lint. The plaster is made by kneading fine barley meal in vinegar and boiling to make it as glutinous as possible. Then when you remove the lint packing on the next day, look down at what the bone has suffered. If on inspection, the injury is not obvious to you, or what type injury there is in the bone is not obvious, or you cannot determine if some malady in itself involves the bone or even if nothing is involved, and if it seems the weapon hit the bone and injured it, you

must (20) scrape with the scraper up and down the depth, lengthwise as the patient is oriented and back again across the bone, so as to see hidden fractures and hidden contusions which are not depressed inward from the natural position of the rest of the skull. For the scraping picks out the malady very well (25), even if these lesions from the weapon are in the bone but are not themselves otherwise obvious. If you do see a *Hedra* from the weapon in the bone, you must scrape the *Hedra* itself and the bone surrounding it (30), lest a fracture and contusion or a contusion alone which commonly complicates the *Hedra*, being subtle, would then not escape notice.

Whenever you scrape the bone with the scraper, if you think that the trauma to the bone may require a burr hole, you must operate, and do not exceed three days without doing the procedure, but operate within those days, and especially in the warm season, if you undertake the treatment from the beginning.

If you suspect the bone to have fractured or to have been contused or both, after concluding that the victim had been injured severely from the description of his trauma (40), and that he had been injured by a very powerful assailant, if one was struck by another, and that the weapon with which he was injured was among the dangerous weapons, and also that vertigo and a blackout seized the man and he was stunned and he fell down, when these are the circumstances and if you cannot determine if the bone has fractured or has been contused or both, looking at it or even in another way, then you must pour an ultra-black solution upon the bone, and prepare the wound with the soluble black medicine, putting it under a little linen cloth wet with olive oil (50). Then bandage it after packing it with the barley-meal plaster. On the next day after opening up and cleaning the wound, scrape it. If it is not intact, but has fractured and has been contused, the other bone will be white after being scraped but the fracture and the contusion, after the medicine has dispersed, absorbs the medicine to itself becoming black and it will blacken in contrast against the rest of the white bone. But you must scrape again this fracture which appears black, down to the depths. And indeed if after scraping [this same fracture outlined by the black] (60) you clear it up and make

it disappear then the bone has a contusion more or less severe which also has broken around it but the fracture disappeared with the scraping. Less concern and consequence arises from such a fracture which was erased. If, however, it is down deep and not prone to go away when scraped that situation comes to surgery. After operating on the wound you must treat the consequences of the wound.

XV

You must guard against the bone developing a malady from the flesh if it is badly treated, for suppuration is more likely in bone after the burr hole and also when stripped other than by surgery. For in the bone stripped by surgery or otherwise without surgery, whether uninjured by the weapon or seemingly uninjured, there is a greater danger to have infection (purulence), even if it would not happen otherwise, if the tissue surrounding the bone is treated badly and it festers and constricts (10). It gets warm and there is a lot of abundant inflammation and indeed the bone pulls in both heat and inflammation from the surrounding tissue to itself as well as throbbing and irritability. In addition to the things just mentioned the purulence occurs from whatever toxicity the flesh might have in itself. It is also a bad sign for the soft tissue in the wound to be wet and oozing and to require a long time to clear up. But you must make the wound suppurate as quickly as possible for thus the part surrounding the wound would fester much less and would be clean most quickly. The tissue which is crushed and contused by the weapon is bound to melt away as it becomes purulent. Whenever the wound becomes clean, it must become fairly dry for thus it would heal most quickly, because the dry tissue heals and not the wet, and thus the healing wound would not hypertrophy. The same idea also holds for the dura around the brain (30), for if after cutting out the bone and immediately freeing it from the dura, you expose it, then you must clean and dry it as quickly as possible, so that by not remaining wet for a long time it will not ooze nor macerate. For when things like these happen there is a risk of necrosis.

XVI

Indeed any bone which is liable to separate from the other bone retracts after it becomes bloodless for the most part following a head wound in which there is a *Hedra* from a weapon in the bone, or when the bone otherwise has been largely denuded. For the blood dries out of the bone both from time and from most treatments. It would separate most quickly if, immediately after cleaning the wound, one would dry both the wound and bone either in a larger or a smaller lesion (10). For when the bone has dried out very quickly, being dry as a pot shard, in that state it readily separates from the other bone which is bloody and alive; bone that has become bloodless and desiccated easily separates from the bloody and living part.

XVII

Among the cases of contusions with the bone depressed from the natural position those which have a deep fracture or even are fragmented all across are less dangerous as long as the dura is intact. The cases with multiple fractures which are broken down inwardly and those with fairly broad fractures still have a quite innocuous course and have very little trouble in the debridement. It is not necessary to place a burr hole in these cases at all, nor to cause danger attempting to remove the bones before they let loose on their own. They are likely to loosen early and are pushed up from the flesh growing back under the bone. It grows back from the diploic part of the bone and from the intact bone if there is necrosis only of the upper portion of the bone. The flesh will fill in very quickly and thus proliferate and the bones realign if one makes the wound suppurate as quickly as possible after cleaning it. If the lesion is entirely through both parts of the bone, both the upper part of the bone and the lower part, and they are staved in to the dura, it will heal quickly by treating the wound in the same way as above (20), and the bones which were staved in quickly realign.

XVIII

The bones of children are both thinner and weaker for the following reason: They contain more blood, are hollow, porous and neither compact nor firm. The skull in a younger child begins to suppurate more and faster than that of an older one, and in a shorter time, when the injury comes from equal weapons or weaker ones and if wounded similarly or even less. When the trauma is likely to be fatal, the young child dies more quickly than the older one (10).

But if the bone is stripped of flesh, being mindful you must, try to determine that which is not visible to the eyes and you must recognize if the bone has fractured and contused or has contused only. In addition if there is a *Hedra* from the weapon, you must know if there has developed a fracture, contusion or both. If the bone has suffered such things release the blood by drilling the bone with a small drill checking it frequently. For the bone is very thin and very close to the surface in young ones compared to older ones.

XIX

A patient who is likely to die from the head trauma and is one you are not able to remedy or to save, requires you to predict from these signs the likelihood of dying and foretell the other things that will happen. Such a patient suffers the following things:

Whenever the bone has broken to pieces or shattered or is contused or at least in some way has broken, and someone, after considering it, is mistaken and does not scrape nor drill, nor sense the need to, as though the bone were intact, then fever takes over (10) in 14 days as a rule in the winter and fever strikes after 7 days in the summer. When this happens the wound becomes colorless and a bit of serous fluid flows from it and the inflammation dies away. A clammy stickiness occurs and it looks just like cured meat, the skin is reddish yellow, somewhat livid. The bone begins to necrose by this point: still being smooth it becomes dusky, and finally becomes yellowish or off white (20). Whenever there already is a

suppuration, blisters occur on the tongue and the delirious victim comes to his end. Spasms strike the parts on one side of the body in most cases. If the weapon comes to a place on the left side of the head spasm strikes the parts on the right side of the body. Alternately if the weapon comes to a place on the right side of the head the spasm strikes the parts on the left side of the body. There are those who have paralysis and die thus in seven days in summer and in fourteen days in the winter (30). These signs mean the same thing in trauma of the adult or of the youngster.

If you realize that fever is striking the patient and there are some signs to support this you must not waste time (35), but you drill the bone to the dura or scrape it down with the scraper—the bone is compliant and easy to scrape—then manage the remaining problems as it seems indicated by watching the result.

XX

Whenever there is head trauma in a man and the bone has been stripped, either in one whom has been operated upon or not, an erythematous edema and erysipelas forms in the face and in one or both eyes. If one touches the swelling it is tender and a fever and chill strikes. But the wound itself seems to be doing well and the condition of the flesh, the bone, and the surroundings of the wound are doing well (10) except for the facial edema and the edema does not come from any error of other treatment, then in this case you must purge down the lower bowel with medicine which draws away the bile. After the purging the fever breaks, the edema subsides and healing occurs. You must administer the medicine while monitoring the vigor of the man with regard to his strength.

XXI

When it becomes necessary to place a burr hole in a man you need to know the following about the procedure: If you operate having taken on

the case from the beginning, you need not excise the bone immediately from the dura. For it is not beneficial for the dura to be stripped from the bone and be exposed to risk for a long time and it may even become macerated after a while. Also another danger is that you damage the dura during the procedure with the saw if you immediately remove the bone which is excised from the dura (10). When you saw to the point that you need to saw through only a little more and the bone actually moves while sawing, you must stop sawing and let the bone separate on its own. For no harm will supervene in the bone which was sawed and has been left behind from the saw for the remainder is already thinned. Treat the remaining things as it seems to benefit the wound.

While sawing you must remove the saw often and submerge it into cold water because of the warmth of the bone, for the bone is heated up by the rotation (20) of the saw and becoming hot and dry the bone burns causing the saw to remove more surrounding bone than was intended to be removed. If you want to saw through the bone to the dura immediately, and then remove the bone, you must likewise remove the drill often and plunge it into cold water.

If you did not undertake the management from the beginning but you receive it from another, and have come late for a cure (30), you must saw out the bone immediately with a notched blade right to the dura and taking the saw out often, look closely and check with both the probe and other ways down around the path of the drill for the bone is sawed through much more quickly if it has already begun to suppurate and is purulent throughout. And the bone may be shallow especially if the trauma is in that part of the head in which the bone happens to be very thin rather than very thick. But you must watch out so that you do not misdirect the saw (40), but always set the saw in the spot where the bone seems to be thickest, observing it frequently, and while going to and fro try to lift the bone. After taking it out, manage the rest as seems beneficial for the wound watching for what happens.

If you take on the management from the beginning and when cutting out the bone and you want to remove it from the dura immediately you must in the same way described examine the circular path of the saw with the

probe, always (50) set the saw in the thickest part of the bone and with alternate motion strive to remove the bone. Having taken the case from the beginning, if you use an auger do not go down to the dura with the auger, but you must leave behind a thin residual of the bone just as noted for the saw.

7

Hippocratic Medicine and Neurologic Conditions

Ancient Greek ideas concerning the nervous system can be found in the Hippocratic texts, which represent a variety of authors who wrote mostly during the fourth century BCE. This chapter reviews the background of the Hippocratic physicians and then identifies their ideas that pertain to neurological conditions and the brain. The references to the brain were obtained with a search of the *Thesaurus Linguae Graecae* and from other sources cited in the text.

THE HIPPOCRATIC MEDICAL PRACTICE

Medical practice in ancient times was a free-for-all: no licenses, no credentialing, no regulation. There were medical schools that taught the elements of medical practice, but the ultimate credential was reputation. There were healers trained in temples and other practitioners who offered treatments based on their general experience. Here is the opening from the fourth-century Hippocratic treatise, *Law*, which may have been an address to medical trainees:

> Medicine is the most distinguished of all the arts, but through the ignorance of those who practice it, and of those who casually judge

> such practitioners, it is now of all the arts by far the least esteemed. The chief reason for this error seems to me to be this: medicine is the only art which our states have made subject to no penalty save that of dishonor, and dishonor does not wound those who are compacted of it. Such men in fact are very like the supernumeraries in tragedies. Just as these have the appearance, dress and mask of an actor without being actors, so too with physicians; many are physicians by repute, very few are such in reality.[1]

The successful big-city physician practiced at his office, which was complete with drugs, instruments, and other equipment for treating surgical conditions. The office was for consultation for patients with new maladies, but the doctor made house calls routinely either for consultation or to visit sick persons at home where they received treatment. There were also itinerant physicians who went from town to town carrying their gear and using local facilities to practice in places where there were no resident doctors. The treatise *On Airs, Waters, and Places* was written to instruct peripatetic physicians how to predict illness and choose treatment in different environments. Some towns (and some rulers outside Greece) hired a municipal physician for a year or two to ensure at least one doctor was available to them. The doctors who were candidates for a city's public physician were interviewed by the town's general legislative body and first had to be glib and then to convince the laypeople of their competence. Their reputation was based not only on their success with cases but also on their ability to discuss, argue, and embellish their image of medical authority. The physicians charged fees and were encouraged to treat rich and poor alike, a practice that is attested in the cases recorded in the *Epidemics* that describe patients and their treatment. Slaves and freemen as well as foreigners were treated. Some physicians must have been slaves themselves, but there is little to know about how they worked. The freemen doctors certainly treated the slaves. The fees were probably determined by the ability to pay, so that the wealthy paid enough to allow the poor to pay fees that they could afford.

Pathology and physiology were not universally agreed on by the ancient physicians in an organized way. The authors of the Hippocratic texts determined causes and offered treatments that varied widely and were often in direct opposition, depending on their conceptual bias. The medical disorders were identified by their clinical manifestations or from a type of malfunction that seemed likely. The clinical details in the texts are superficial, so the descriptions are not specific in a modern sense but could designate several possible etiologies. The idea of etiology was really not recognized as a specific feature of disease because there were few objective data to differentiate causes. The causes of maladies were concocted, as we will see, from balances and imbalances of a set of bodily elements. Some diseases were associated with specific organs based on external observation or derived from speculated internal causes.

The core of Hippocratic treatment was a *regimin* that manipulated the diet, exercise, and other aspects of the patient's lifestyle. The time of year influenced the specifics of the regimin prescription and is reminiscent of our idea of "health maintenance" programs. The physician could prescribe a treatment plan more or less costly of time and expense depending on the patient's economic status. The author of *Regimin III* prescribed a detailed lifestyle prescription of foods, exercise, baths, and degree of sexual intercourse, all syncopated with the season.[2] He noted that his prescription was for patients "if their circumstances allow." In the next section, he admitted that everyone cannot spend all they have for health, although it was indeed worth everything. Here is the regimin for winter, for the majority of people—a plan we might also consider:

> Now in winter it is beneficial to counteract the cold and congealed season by living according to the following regimen. First a man should have one meal a day only, unless he have a very dry belly; in that case let him take a light luncheon. The articles of diet to be used are such as are of a drying nature, of a warming character, assorted and undiluted; wheaten bread is to be preferred to barley cake, and roasted to boiled meats; drink should be dark, slightly diluted wine,

> limited in quantity: vegetables should be reduced to a minimum, except such as are warming and dry, and so should barley water and barley gruel. Exercises should be many and of all kinds: running on the double track increased gradually; wrestling after being oiled, begun with light exercises and gradually made long; sharp walks after exercises, short walks in the sun after dinner; many walks in the early morning, quiet to begin with, increasing until they are violent, and then gently finishing. It is beneficial to sleep on a hard bed and to take night walks and night runs, for all these things reduce and warm; unctions should be copious. When a bath is desired, let it be cold after exercise in the palaestra; after any other exercise, a hot bath is more beneficial. Sexual intercourse should be more frequent at this season, and for older men more than for the younger. . . . Such is my advice to the great mass of mankind, who of necessity live a haphazard life without the chance of neglecting everything to concentrate on taking care of their health."[3]

The author had a more expensive alternative for "a man favorably situated, and convinced that neither wealth nor anything else is of any value without health"[4] The system resembled ours in that the wealthy got more care than the poor if they paid for it and the Greeks did not hide the fact as we do.

The secular physicians who established themselves as experts in healing were generically known as the Asclepaediae. They were men taught medical skills, by a medical family vaguely connected to Asclepius, the traditional god of healing. By the time of the Hippocratic physicians, the term did not necessarily indicate a family member or a temple practitioner but someone from the medical sects, like those at Cos and Cnidus, who practiced and taught medicine. The physician depended on reputation for credibility so that the practice of medicine required showmanship as well as medical success to maintain the practice. Competence was gauged by successes and one of the important principles to the secular physician was to know the signs of poor prognosis so he could stop treating a patient to avoid the stigma of failure. The etiology was minor (and

unknowable in detail) compared to the awareness of the consequence of the condition.

Competition for patients among physicians and other healers was avid in the large cities. The physicians held public lectures and demonstrations, and indeed they sometimes performed their treatments in front of an audience. Other physicians might show up to a patient's house during a treatment and begin to offer alternative plans. The other formidible competition was with the healing temples of Asclepius. The shrines were managed by priests, who offered treatments and expected some reward for the service. They used prayers and rituals to the gods to relieve illness; in fact, their efficacy was probably acceptable given the outcomes for any form of treatment. Temple medicine was accepted and active throughout antiquity, at least as a backup when other treatment did not help (see Chapter 3).

MEDICAL IDEAS OF THE HIPPOCRATIC PHYSICIANS

The Hippocratic technical expertise is best revealed in the surgical texts in which explicit directions are given based on externally observed phenomena for the treatment of mechanical conditions. *Wounds of the Head*, for example, instructs a doctor about placing a burr hole and provides a valid warning of the possible risks. The author of *Joints* left us an explicit description of spinal cord injury when there is a subluxation of the vertebral column: "The cord, then being compressed and intercepted, would produce complete narcosis of many large and important parts."[5] He also pointed out that a lesser vertebral injury would have a less dire consequence. When the pathology was identifiable, the best physicians could correctly predict at least the likely clinical outcome.[6] The level of concrete observation described in surgery stands out from the fanciful physiology that forms the basis for the Greek explanation of internal diseases.

The Hippocratic physicians used internally consistent reasoning based on a belief in predictable natural causes to concoct their views of internal medical pathology. Their thinking was without a firm basis in fact, but we

have credited them with the feat of making medicine at least logical if not really "scientific." Their practice was on the one hand based on external observation and on the other based on reasoning by analogy to explain what they could not observe. They saw fluids being formed by the body in health and disease, and they observed breathing and air exchange, blood flowing from wounds, and scabs forming during wound healing. They observed the heat of a febrile patient. The observable features of ill patients provided the basis of their explanation of unobservable physiology and pathology of illness. Jouanna has explained the Greek thought process as the reconstruction of the invisible internal problem through analogy with visible observations in humans or elsewhere. The process of finding an analogy in experience that might explain illness led the physicians to posit the boiling, clotting, and separation of the elements in the body as one might see the ingredients change in cooking or in other transforming phenomena like incineration or freezing.[7] The individual Hippocratic authors had different ways of describing the body's function, but the dearth of true knowledge easily allowed the variety of explanations, few of which have any relevance to the actual biologic situation.

As taught by the natural philosophers, the physicians saw a background force that directed the balance of nature. They believed that there was a balance of the universal elements that made the body healthy, and an imbalance caused disease.[8] The Hippocratic doctors had limited anatomy, no true physiology, and only a vague method to test their hypotheses other than by thought experiments. Although they lacked the facts on which to explain illness and disease correctly, they did establish, as crucial, the idea that natural causes direct the changes in man's body and control disease and health. They had observed that the seasons come and go predictably thus it was obvious to any observer that "nature" was largely a predictable system despite the unexpected and extraordinary events that were traditionally explained by supernatural influence. As the understanding of natural phenomena deepened over the centuries, there was less need of divine explanation because the predicted outcomes were proved correct. The explicit acceptance of the regularity and predictability of nature increased as the physicians were better able to identify cause and effect

in the way the world worked as well as in a man's body. That progress allowed their escape from supernatural and magical explanation.

The Hippocratics were explicitly aware of the determinate character of natural events, and they identified the regularity of natural cause and effect from their observations despite and in addition to their tendency toward speculation. The speculation was not based on supernatural conditions but on a construct of humoral physiology. In the work *Ancient Medicine*, the author reviewed the function of observation and separated the techniques of philosophy and medicine. He rejected the dependence on a philosophic assumption or *hypothesis*, which provides a single assumption like an axiom in geometry to explain medical phenomena. The study of cosmic questions, he said, may need an *a priori* postulate to allow an explanation because there is no access to facts about the system. However, the facts of medicine are accessible through observations and experience, and they direct the conclusions for its understanding.[9]

Celsus, who wrote from the vantage of Rome in the first century BCE, said that "Hippocrates of Cos, memorable above all others, separated this branch of learning from the study of philosophy, he was a man notable for experience and eloquence."[10] Hippocrates is credited for separating medicine from religion and philosophy, but medical thought was infantile, allowing it to invent causes and misinterpret observations, and the Hippocratic rationality ultimately was unable to resist the philosophic whirlwind engendered by Plato. During the Hellenistic period and beyond, the long-standing religious influence rose to lead medical thinking with metaphysics and philosophy, a trend that persisted throughout antiquity. Platonic idealism took root and stifled the practice of rational science and medicine, sinking it back into speculation and spiritualism.[11]

The "Hippocratic physician" or "Hippocratic thought" is a generalization far too diffuse to identify a single physician or even a single school of thought (see Chapter 2). Nevertheless, the medical concepts that are contained in the *Corpus Hippocraticum* do have a unity that is emblematic of the secular practice of medicine of the fourth century. The Hippocratic texts are grounded on several characteristic ideas that distinguish them in their concept of medical practice. They taught first that disease has a

natural history that allows a physician to anticipate the outcome (prognosis) by observation and by understanding the nature of the disease. Second, the Greeks believed that disease is caused by knowable disturbances of the body and by influences of the environment. As the author of *On the Sacred Disease* said: "Each [disease] has a nature and a power of its own and . . . none is incapable of treatment."[12] They also taught that there is a natural tendency for the body to correct the disturbances in its functions and to heal itself. They recognized a timeline of critical days within which natural healing would or would not occur, and they identified the effects of the winds and climate on the incidence of illness, perhaps based on their experience with malaria and other infections. The physician's role was to facilitate the body's own ability to heal itself by providing the optimum environment to maintain a balance of the bodily elements.[13]

THE INTERACTIONS OF OPPOSITES AND THE "HUMORS"

The ancient Greek physicians constructed a theory of medicine to explain their observations, to conjure the cause for unobservable pathophysiology, and to suggest a treatment strategy. Disease was not seen as an external force but as an innate imbalance of the constituents of the body. One of the key medical concepts that developed out of natural philosophy was the influence of opposites and the metamorphosis of the constituents of the body from one form to another. From that general notion of opposites came the humoral theory of health and disease that persisted until the modern age of medicine. There was no single humoral theory among the ancient physicians; indeed, some authors did not mention humors at all. The idea of "balance," however, was pervasive in the thinking about diseases, and the humors were part of the expression of those concepts.

The humoral theory grew from the idea of opposites (hot, cold, etc.) to include four elements: black bile, yellow bile, blood, and phlegm. The humors were associated with the seasons and with the effects of warming and cooling. There were forces construed as the basis for causing the

imbalance of the components of bodily function. As long as all the forces were equally active and the components were balanced, there was health; if one force prevailed, there was disease. The melding of the forces was called *crasis*. The medical concept of the humors was concrete and as real to the Greek physician as DNA is to us. The description from *The Nature of Man*, written by Polybus, not Hippocrates, gives us a summary of the humoral concepts:

> For there are many constituents in the body which by heating, by cooling, by drying or by wetting one another contrary to nature, they engender diseases.[14]

Also:

> The body of man has in itself blood, phlegm, yellow bile and black bile; these make up the nature of his body, and through these he feels pain or enjoys health. Now he enjoys the most perfect health when these elements are duly proportioned to one another in respect of compounding, power and bulk, and when they are perfectly mingled.[15]

Alcmaeon of Croton (*floruit* early fifth century) was an early physician, perhaps under the influence of the Pythagorean school, who laid out the concept of a balance of an infinite number of elements to preserve good health:

> Health is the equality of rights of the functions, wet-dry, cold-hot, bitter-sweet, and the rest; but single rule among them causes disease; the single rule of either pair is deleterious. Disease occurs sometimes from an internal cause such as excess of heat or cold, sometimes from an external cause such as excess or deficiency of food, sometimes in a certain part, such as blood, marrow or brain; but these parts also are sometimes affected by external causes, such as certain waters or a particular site or fatigue or constraint, or similar reasons. But Health is the harmonious mixture of the qualities.[16]

This concept from Alcmaeon and the pre-Socratic philosophers provides the general notion of the humors, but the details varied among the authors of the *Corpus Hippocraticum* over the years. The humors and their blending to create and preserve health was a central theme in the Greek concepts of pathophysiology.[17] The Greek physicians, however, were not bound to the concepts that the natural philosophers had enunciated; in fact, much of the philosophic abstraction was dismissed, leaving observation as the major guide for practice.

The author of *Ancient Medicine*, for example, regarded managing the opposites as trivial and flatly stated that the philosophic concepts of man's origin are irrelevant: "Everything that philosophers or physicians have said or written about natural science no more pertains to medicine than to the art of writing."[18] He castigated those who simplify disease to a mere mismatch of opposites. He created an equally speculative, diverse system but at least realized that human biology is not simple.

Medical thinking argued from analogy to explain the hidden illnesses; at the same time, it was able to use observation of clinical signs to infer the outcome and severity of the illnesses. The subtle shift to inference in making real-time diagnostic and prognostic decisions is another credit to rational thought in Greek medicine. The inferential method is certainly familiar to modern neurologists, whose practice up until only a few decades ago depended on interpreting the clinical signs of neurologic dysfunction to localize and quantify neurologic disease. Now, neurological imaging has nearly replaced the need for interpreting the clinical signs to localize neurological disorders. The same change occurred for the cardiologists after cardiac catheterization and echocardiography made clinical examination in cardiology all but irrelevant.[19]

In general, however, Greek medical thinking engaged the balance and change in the contrary conditions hot, cold, moist, and dry to influence the humors in most of the Hippocratic authors. The transformation and the optimal equilibrium of the humors, similar to the balance of the forces, was described as a process named *pepsis*, which is traditionally translated as "coction," a word that does not have meaning for the modern reader. The coction is used in nonmedical writing to indicate

the ripening of fruit, the changing of food as it is cooked, and the fermentation process to make wine. The term implies an essential change in the substrate (e.g., under the influence of heat). The doctors seemed to believe that the humors could separate into dominant entities and then by a special process of reorganizing (viz., coction), the humors could combine and completely transform into a different entity that achieved a more favorable balance for health. The change may be associated with the body heat, and it created a new substrate; it was not a mixture and not even a compounding but in fact a substance different from the constituents. One can speculate that the idea might arise from observing the healing of a wound, with the wound starting out bloody, developing serosanguinous fluid, scabbing over, and then healing to near-normal flesh. The author of *Ancient Medicine* offered an example of bread, which when baked can turn out differently when the ingredients are different. He defined *coction* as a combination of "mixture, compounding and digestion."[20] Therefore, the Greek physician could conclude that "man is in the best possible condition when there is complete homeostasis (coction) and at rest, with no particular property displayed."[21] Coction was also part of the evacuation or release of the offensive, corrupt humors that allowed the "crisis" or denouement of the malady. The thinking about coction is spelled out in this case from *Epidemics* I, which also described the basic medical method used by the Hippocratic physicians:

> In all dangerous cases you should be on the watch for all favorable coctions of the evacuations from all parts, or for fair and critical suppuration. Coctions signify nearness of crisis and sure recovery of health, but crude and unconcocted evacuations, which change into bad suppuration, denote absence of crisis, pain, prolonged illness, death, or a return of the same symptoms. But it is by a consideration of other signs that one must decide which of these results will be most likely. Declare the past, diagnose the present, foretell the future; practice these acts. As to diseases, make a habit to do two things: help, or at least do not hinder (recovery). The art has three factors, the disease, the patient, the physician. The physician is the

> servant of the art. The patient must co-operate with the physician in combating the disease.[22]

The abstract concepts of Greek pathology are fanciful to the mind of modern medicine, and the details of ancient pathophysiology may seem ludicrous to us, but the Greeks recognized that illness was comprehensible, and their powerful observational skill makes the best Hippocratic works a model for creative thinking in science as well as medicine. One might project our own ideas 2,400 years hence and wonder if our arrogance in knowledge will be dismissed as easily.

NEUROLOGICAL CONCEPTS IN THE *CORPUS HIPPOCRATICUM*

The Hippocratic descriptions of neurologic illness follow the general medical notions of climactic influence and humoral pathology as it applies to the disorders of the brain and spinal cord. Neurologic disorders are specifically discussed in a few of the Hippocratic texts, and the texts vary in date and emphasis so we can only compile an amalgam of the Hippocratic neurologic concepts that can serve as a guide to the general understanding found in the *Corpus*.

The Greeks saw the pathology of nervous disorders, as attested in *On the Sacred Disease*, as a reaction of the brain substance to heat or cold and its subsequent melting to pour forth fluids, as *katarrei*, rendered as fluxation. The fluxation is conceived as emanating from the brain tissue as phlegm and less often as bile that flows down to the rest of the body.[23] Changes in the volume and quality of phlegm, bile, and blood determine the state of the brain. The degree and viscosity of the flowing substances influence the state of health in the brain.

There are diseases called "thick diseases" in which the flows are excessive and viscous. One such thick disease causes pain in the head, speechlessness, and paralysis.[24] The idea of fluids flowing to cause disease of the brain probably comes from the secretions from the nose, eyes, and

ears that the doctors observed in clinical practice.[25] The brain tissue was considered to "melt" during illness and on recovery to dry and harden. In some diseases, the quality of the blood was the problem, and it was thought to "boil" when the brain was overheated: "The brain also warms whenever a lot of blood enters into it and it seethes."[26]

The concepts of the breath (*pneuma*) and the air combined with the humoral theory play an important role in the Greek explanation of neuropathology. The activity of the breath in allowing the body to function provides a leading premise of health and disease. The breath animates the organism and allows speech and cognition, and when the breath is obstructed by phlegm or bile, the body becomes ill. The fluxation, besides having a direct pathologic effect, impedes the *pneuma* and thereby causes the disorders of brain, which in turn affect the other parts of the body. "Speechlessness occurs when the phlegm suddenly enters the vessels. It shuts out the air keeping it from the brain."[27]

The constructed pathophysiology did not direct better treatment of diseases, but no matter the fallacy, the Hippocratic physician believed in his constructs; he used them to spin more complex associations, to explain pathophysiology, to define clinical features, and to determine options for a regimin or a lifestyle and especially a diet that fostered health and excluded illness. Without other interventional remedies, the prevention of illness and the modification of symptoms was based on lifestyle manipulation, a concept that still has merit.

Modern speculative medical thinking about some diseases when facts are sparse resembles the thinking of the Hippocratic physicians. Until just recently, before genetic and neurochemical definitions began to emerge, we described a whole series of neurologic illnesses (e.g., Alzheimer disease) as "degenerative" without any other qualifiers. There were no data to explain the wasting of the tissue, and numerous attempts to speculate a cause were tried and abandoned. The obvious difference between modern and ancient medical practice is our ability to test a hypothesis and to discard those that prove to be erroneous. We are still struggling with a coherent biological explanation of the degenerative diseases like Alzheimer disease, but our methods, unlike in fourth-century Greece,

do not allow pure speculation, at least not for long, without validation by objective data. A more tenacious parallel in modern practice with the ancient Greeks is the neighborhood practitioner who espouses the notions of aromatherapy, herbal treatments, or diet therapy and those who believe that the body is best left to heal itself. The holistic medicine movement is a page out of Hippocrates, and there are modern practitioners who use the concepts of breaths, diet, and regimin to enhance health. The overriding mantra for some modern practitioners is a "balance" in the elements of the body and in behavior, which is in itself a fail-safe position depending on the details. The outcomes are probably similar to those of the ancient doctors. The practitioners of today who treat symptoms and illness with colonic irrigation and other means of purging the body of its toxins also follow similar methods attested in the *Corpus Hippocraticum* and are generally focused on similar myths.

DISORDERS OF THE BRAIN IN THE *CORPUS HIPPOCRATICUM*

The *Corpus Hippocraticum* discusses neurologic function, pathology, and clinical observation in terms that are sometimes recognizable to the modern reader. Many Greek terms have been used to describe modern medical phenomena so that we feel familiar with their expression, but one must remember that the ancient usage probably had little to do with what we think. The Greeks use of observation of bodily fluids helped to organize their concepts, but in modern medicine specific anatomic, physiologic, and chemical data establish an etiology. The data for an etiology was not available to the Greeks, so their approach was different, making the explanations for many disorders incompatible with modern constructs of disease.

Human anatomy, physiology, and pathology that have been defined in the 21st century are in fact the same as existed in the fourth century BCE. There is no reason to believe that there were differences in the basic biology of humans. The experience of medicine, however, was completely

different to the Greeks because of the medical misunderstanding and because of life span, sanitation, risk of trauma, infections, and many other external factors that determine the incidence and prevalence of specific conditions. However, we can look with care at their work and still see common threads in what they saw and what we know. The risk of anachronism aside, that is the point of the next section.

SPHAKELOUS DISEASES

Among the unfamiliar neurological concepts of brain disease is *sphakelizo*, a verb meaning "to be *sphakelous*" (literally: to become rotten, necrotic, ulcerated, etc.). "The brain becomes sphakelous" is a phrase used by the Hippocratic physicians to indicate a neurologic illness that denoted a specific medical condition. The word does not occur in Homer. Herodotus (480–430 BCE) described osteomyelitis or other necrosis of bone using this term.[28] The term occurs in the *Corpus Hippocraticum* mostly in the context of post-traumatic complications to the bones or tissue.[29] It is used to describe the "mortification" of the jaw with an abscess; indeed, one ancient author said he would discuss the phenomenon when he discussed draining abscesses.[30] The term was used to denote the consequences of festering tissue, which can develop into a systemic syndrome with fever and death. It is variously translated into English as "necrosis" or "mortification" and is similar to gangrene but indicates a more fulminant process than when used by Galen in the second century CE.

Sphakelous is used by the Hippocratic physicians to identify a specific malady of the brain that causes a dissolution of the brain tissue to produce excessive phlegm. The brain becomes sphakelous with pain in the head that moves down through the neck to the spine; the patient becomes deaf and suddenly develops speechlessness. He will have pallor and blood from the nose. There may be sweats and loss of consciousness, and the person may vomit blood. The spinal cord is also involved.[31] The course is measured in days, and few escape death.[32] The Greek physicians

determined that the brain either overheated or overcooled from excess phlegm or bile. Osteomyelitis may be one modern interpretation of the bone and tissue cases, but sphakelous disease of the brain is a neurologic entity not entirely specific but reminiscent of acute meningitis or encephalitis. Subarachnoid hemorrhage is also a possibility, and the Greek physician could not have made the distinction. There are no postmortem data in Hippocratic practice because it was anathema for them to disturb the body of the dead.

RECOGNIZABLE NEUROLOGIC CONDITIONS FOUND IN THE *CORPUS HIPPOCRATICUM*

Unilateral weakness: *paraplektios* ("paraplegia"). This term and its cognates appear frequently (93 times in the *Corpus*) to describe paralysis of one side of the body or in the legs. The word comes from the root, = *plek*, which means "be struck" with the prefix *para-* meaning "on the side of." The term was not used to mean paralysis of the legs, as used today, but a unilateral weakness. The term hemiplegia does not occur in the work of Hippocrates, Aristotle, or Galen. The term appears in the seventh-century CE medical writings of Paulus Aegineta.

In a discussion of the flow of phlegm running down from the brain, the author of *Airs, Waters, Places* described what we might assume is hemiplegia: "Old men have catarrhs because of their flabbiness and the wasting of their veins, so that some die suddenly, while others become paralyzed on the right side or the left."[33] And in another place: "They [men over 50] are paralyzed by catarrhs supervening from the brain, when the sun suddenly strikes their head or they are chilled."[34] The author of *Epidemics* I also describes a syndrome that causes paralysis in the older patient:

> Pains about the head and neck, and heaviness combined with pain, occur both with and without fever. . . . Those with pain in the neck,

> heaviness of the temples, dimness of sight, and painless tension in the hypochondrium, bleed from the nose; those with general heaviness of the head, heart pain, and nausea, afterwards vomit bile and phlegm. Children for the most part in such cases suffer chiefly from convulsions. Women have both these symptoms and pain in the womb. Older persons, and those whose natural heat is failing, have paralysis or raving or blindness.[35]

The Greeks were aware that a brain lesion caused a contralateral motor deficit of the body. Cerebral lateralization is described in cases of head trauma, but the word used for the observed contralateral deficit is "spasm" (*spasmos*), so it could mean weakness, hypertonia, or focal seizure. Following head trauma, "most cases have spasm of the parts on one side of the body; if the patient has the lesion on the left side of the head, spasm seizes the right side of the body; if he has the lesion on the right side of the head, spasm seizes the left side of the body."[36]

Some commentators have identified polio as the pathology in this report in the *Epidemics*:

> In this settlement during winter a paralysis began which attacked many, a few of whom quickly died. In fact, the disease was generally epidemic. In other respects the public health continued good.[37]

Sudden loss of consciousness, paralysis, and collapse: *apoplektos* ("apoplexy"). This is a more extensive and generalized malady than paralysis: "The mind is deranged, and the brain pulls and convulses the whole person, who sometimes becomes speechless and is suffocated; the name of the disease is apoplexy."[38] The term appears 36 times to describe an acute neurologic disaster. It implies a bilateral deficit in most instances, at least at the onset. It is used in the sense to "be utterly struck away." The arms, legs, and voice are affected: "Patients become permanently disabled because of the following: they have strokes that affect the movement of their arms and legs, they lose command over their voice, and they

become paralyzed as the result of dark bile."[39] The term *apoplexy* was used in modern medicine until a few decades ago to indicate a cerebral hemorrhage, but Greek use was probably not so specific.

Stroke: *hoi bletoi*. This means "those struck," usually by paralysis or apoplexy, but it is also used alone. The deficit is sudden and severe.[40] The authors described speechlessness, paralysis, poor vision, and other findings in persons who had a stroke. The prognosis was not good: "If a person is stricken, he has pain in the front of the head, he does not see properly and he is drowsy, the vessels throb, there are mild fevers and powerlessness of the body."[41]

RANDOM "PICKING" BEHAVIOR IN DELIRIOUS PATIENTS

Picking at the bedclothes and at imaginary objects (carphology and floccillation, respectively) are characteristic of patients with typhoid fever, typhus, or other infections that cause stupor.[42] It also occurs in acute cerebral hemorrhage or large stroke before the patient becomes comatose. The Greeks described it as a deadly sign: "As to the motions of the arms, I observe the following facts. In acute fevers, pneumonia, phrenitis and headache, if they move before the face, hunt in the empty air, pluck nap from the bedclothes, pick up bits, and snatch chaff from the walls all these signs are bad, in fact deadly."[43]

Seizure: The Greek technical term for seizures is *epilepsis,* "epilepsy," but the Hippocratic authors often described the manifestations of epilepsy or called it "the sacred disease" rather than name it. The technical term occurs only nine times, and it appears only once in the treatise on seizures, *On the Sacred Disease*. That author's clinical observation is accurate even today: "The person becomes speechless and he gags. Froth flows from the mouth, the teeth are clenched and the hands contracted. His eyes are deviated and he loses consciousness. In some cases there is incontinence of stool."[44] The other more descriptive word translated as seizures is *spasmoi* and its cognates. Seizures are associated with paralysis, as in "paralysis that move up from the loins to the neck and head, disabling in

the manner of apoplexy, lead to convulsions and delirium,"[45] and with hysteria, "convulsions in afebrile, hysterical (*huserikos*) disorders are easy to manage."[46] The Greeks did not understand "hysterical" in our psychiatric terminology, but it was associated with a problem in the womb. It seems to fit our concept of being physically benign as in pseudoepileptic seizures.

Convulsions were thought to be from an abnormality in the brain: "The brain solidifies and the blood stands still; consequently the phlegm separates off and it flows down. Such are the causes of epilepsy in children at an early age."[47] Convulsion was also seen to follow the use of hellebore, a herbal toxin used for a variety of conditions[48] (see Chapter 4).

Headache. The specific term for headache is *kephalgia*, but most instances of head pain were described rather than given the technical designation. Headache was generally associated with serious illness by the Hippocratics. It often came with other signs and might have been lethal, especially if there was fever or dyspnea. "Pain suddenly seizes the head and the patient becomes speechless and loses power over himself."[49] Headache was a clinical feature of stroke, as mentioned previously. Benign headache was described in youths and in girls who had their menses.[50] Pain on one side of the head was described as a result of excess bile.[51]

Malaria was likely endemic in parts of Greece, and indeed cerebral and other forms of malaria were described in the texts as specific fevers.[52] Malaria was seasonal and geographic, giving rise to the emphasis on certain places and wind directions as factors in diseases. Headache is a prime feature of malaria, and in endemic areas people develop a degree of tolerance to the parasite so the illness is not as severe as in naïve individuals. There is no mention of *hemikrania* or its cognates, our "migraine," in Hippocrates or Aristotle. The term was used by Galen.

Speechlessness. Loss of the voice, *aphonios*, is a term used in a variety of contexts and may have included failure of language, but it was not our idea of "aphasia." The later Greek word *aphasia*, which does not appear in Hippocrates, was associated with emotional distress and appears regularly as a state of awe.

The aphoristic book *Prorrhetic I* has numerous pithy sayings about speechlessness, which was considered a serious harbinger of death, especially when associated with other signs: "Loss of speech in conjunction with a cataleptic weakness is a fatal sign."[53]

The mechanism of speech was understood in later works as coming from air pushed through the mouth and resonating in the head. The author of *Fleshes* offered the following description: "Speech takes place through the air, by the person drawing it inside his whole body, but mostly into the hollow parts; as the air is forced out through the empty space, it produces a sound through the resonance of the head." The author continued to describe dysarthria: "The tongue articulates by touching: as the tongue encloses the air in the throat and touches the palate and teeth, it gives the sound clarity. If the tongue does not articulate by touching each time, the person does not speak clearly but utters [noises] as [words] are all by nature, mere noises." The same author noted that a person can speak if he closes his tracheotomy. "I have seen persons who have cut their own throats, sever the throat completely; these may live but they cannot speak unless someone closes their throat, then they can speak." He took that observation to mean that it is the air that carries the speech.[54]

Strabismus and coma were observed together in one text*: "In cases where coma comes on after divergence of the eyes [it presages death]."[55] The term *diastrophes* describes anything divergent. Another physician described ptosis: "The closing of an eye in acute disease is a bad sign."[56]

There was a description of a neurologic syndrome accompanying liver disease that provides an insight in ancient bedside physical diagnosis. "Another thick disease: . . . his liver swells up . . . shivering and fever set in. The pupils of the eyes are dilated, the patient sees dimly and if you bring your finger to his eyes, he does not perceive it because he cannot see: this is how you can tell if he cannot see: he does not blink when the finger is brought near." The author continued to describe hallucinations: "There

* Littre omitted the bit about strabismus. This is an example of the ambiguity inherent in the interpretation of the manuscripts. This text was given by Potter.

seem to appear before his eyes reptiles and every other sort of beast." The influence of alcoholism was not indicated.[57]

Facial palsy: Distortion of the face was recognized as either a benign facial palsy or a more pernicious malady: "Distortions of the face if they coincide with no other disorder of the body, quickly cease, either spontaneously or as a result of treatment. Otherwise there is paralysis."[58]

Numbness in the limb or a dullness in sensation or mental acuity was described using words related to *narkon*. The Greeks also named the electric eel *narke*, which is perhaps a linguistic clue to their understanding of the term as paresthesia. Numbness of the whole body was described as a feature of some ailments. One author warned: "Numbness developing suddenly on both sides is a bad sign."[59] Another of the Hippocratic physicians described pain in the shoulders that spreads down the arms, causing numbness and pains distally. It was most common in women between ages 40 and 60.[60] There was nothing else mentioned to establish a cause.

Tetanus and opisthotonus: The Greeks knew tetanus (not the infection) and named it. They associated it as a sequela to a wound and described the clinical features.[61] There are descriptions of tetanus that may be focal and not fatal. Here is one description of generalized tetanus: "When tetanus occurs, the jaws become as hard as wood and patients cannot open their mouths. Their eyes shed tears and look awry, their backs become rigid, and they cannot adduct their legs, similarly not their arms either." And further in the same book: "Opisthotonus is mainly the same but the patient is drawn backward. He sometimes cries out, his pains are violent, and sometimes the disease does not allow him to adduct his legs or to extend his arms; for the elbows become flexed and he holds his fingers in a fist usually enclosing the thumb inside the other digits."[62]

The *Corpus Hippocraticum* has much to say about the brain and other nervous system structures and the Greek physicians had seen a lot of the clinical phenomena that come with neurologic disease. Their idea of the pathophysiology of neurologic diseases, although fanciful in our world, was internally consistent and avoided the religious and philosophical impediments of the past. Although "Hippocrates says" is not quite a

correct rendering of the wealth of neurologic data that is in the collection, a powerful consortium of doctors speaks to us from the medical texts given to Hippocrates. Hippocrates shows us how subtle his neurologic acumen really was when he made this clinical observation that is still germane: "An insolent reply from a polite person is a bad sign."[63]

NOTES

1. The Hippocratic references are to the Loeb edition: Jones, W. H. S., *Hippocrates* I, II, IV, Loeb Classical Library, Harvard University Press, Cambridge, MA, 1923–1931; Withington, E. T., *Hippocrates* III, Loeb Classical Library, Harvard University Press, Cambridge, MA, 1928; Smith, Wesley D., *Hippocrates* VII, Loeb Classical Library, Harvard University Press, Cambridge, MA, 1994; Potter, Paul, *Hippocrates* V, VI, VIII–X, Loeb Classical Library, Harvard University Press, Cambridge, MA, 1988–2012.
2. *Law*, Jones, *Hippocrates* IV, Sections 68–69.
3. *Regimin* III 68–69, Jones, *Hippocrates* IV; Jouanna, Jacques, *Hippocrates* DeBevoise, M. B., trans., Johns Hopkins University Press, Baltimore, MD, 1999, p. 120.
4. *Regimin* III 68–69, Jones, *Hippocrates* IV; Jouanna, *Hippocrates* p. 120.
5. *Joints* 46, Withington, *Hippocrates* III.
6. Jouanna, *Hippocrates,* pp. 312–313.
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8. Jaeger, W., *Paideia: The Ideals of Greek Culture*, vol. 3, Oxford University Press, New York, NY, 1986 (Original work published 1943).
9. *Ancient Medicine* VII, Jones, *Hippocrates* I.
10. Celsus, *De Medicina,* Loeb Classical Library, Spencer, W. G., ed., Harvard University Press, Cambridge, MA, 1935, "Prooemium," 8ff.
11. Jones, *Hippocrates* I, *Ancient Medicine*, Introduction, p. 8.
12. *On the Sacred Disease,* XXI 8–9; see Chapter 4.
13. *On the Sacred Disease,* XXI.
14. *On the Nature of Man,* II 16–20, Jones, *Hippocrates* IV.
15. *Nature of Man*, IV 1–7, Jones, *Hippocrates* IV.
16. Freeman, Kathleen, *Ancilla to the Pre-Socratic Philosophers*, Harvard University Press, Cambridge, MA, 1983, pp. 40–41.
17. Sigerist, H. E., *A History of Medicine*, vol. 2, Oxford University Press, New York, NY, 1961, p. 317ff.
18. *Ancient Medicine* XX 14–16, Jones, *Hippocrates* I.
19. See Jouanna, *Hippocrates* 317ff.
20. *Ancient Medicine* XIX 9–10, Jones, *Hippocrates* I.
21. *Ancient Medicine* XIX 54ff.; VII and XIX, Jones, *Hippocrates* I.
22. *Epidemics* I, XI, Jones, *Hippocrates* I. The Greek can be translated as "to help or at least to do no harm," which sounds like the slogan "*primum non nocere*" but is

not directly connected. The Latin may have emerged in the 17th century and has no ancient correlate.

23. *Airs, Waters, and Places* X, Jones, *Hippocrates* I.
24. *Diseases* ii 6, Potter, *Hippocrates* V; *Internal Affections* 48, Potter, *Hippocrates* VI.
25. *Glands* 11, Potter, *Hippocrates* VIII; *On the Places in Man* 10, Potter, *Hippocrates* VIII.
26. *On the Sacred Disease* XVIII 21; see Chapter 4.
27. *On the Sacred Disease* X.10.
28. Straussler, R. B., ed., *Herodotus*, Pantheon Books, New York, NY, 2007, Book III, 66. The Greek is in Godley, A. D., *Herodotus* II, Harvard University Press, Cambridge, MA, 1982.
29. *Fractures* 11.18–32; *Joints* 33.32, 50ff., 86ff. repeats the material in *Fractures; Wounds to the Head* 17.9 and 19.13, Withington, *Hippocrates* III; *Epidemics* II 5.20; *Epidemics* V 65, 100, Smith, *Hippocrates* VII.
30. *Joints* 50, Withington, *Hippocrates* III.
31. *Diseases* iii 4ff., Potter, *Hippocrates* VI.
32. *Diseases* ii 5ff., 20ff., Potter, *Hippocrates* V; *Aphorisms* 7.50.
33. *Airs, Waters, and Places* X 51, Jones, *Hippocrates* I.
34. *Airs, Waters, and Places* III 23ff., Jones, *Hippocrates* I.
35. *Epidemics* I, XII, Jones, *Hippocrates* I.
36. *Wounds of the Head* XIX 23ff., Withington, *Hippocrates* III.
37. *Epidemics* I, XIV, Jones, *Hippocrates* I.
38. *Glands* 12, Potter, *Hippocrates* VIII.
39. *Diseases* I 3, Potter, *Hippocrates* V.
40. *Diseases* ii 8, 25, Potter, Hippocrates V; *Diseases* iii 1, Potter, *Hippocrates* VI.
41. *Diseases* ii 8; it is repeated in Section 25, Potter, *Hippocrates* V.
42. Verghese, A., "The Typhoid State Revisited," *American Journal of Medicine* 1985; 79(3):370–372.
43. *Prognostic* 4, Jones, *Hippocrates* II; also *Regimin in Acute Disease* (Appendix) 8, Potter, *Hippocrates* VI; *Epidemics* VII 25; *Internal Afflictions* 48; *Critical Days* 3, Potter, *Hippocrates* IX. See also Jouanna, *Hippocrates,* p. 294.
44. *On the Sacred Disease* XIII, XIX. Epilepsy also appears in the following places: *Wounds of the Head* 19, 8, Chapter 4; *Aphorisms* 2, 3, 4, 22, 29, Jones, *Hippocrates* IV, *Coan Prenotions* 587, 2, Potter, *Hippocrates* IX; *Diseases* iii 16, 54, Potter, *Hippocrates* VI; *Affections of Women* 9, 10; *Nutrition* 26, 3, Jones, *Hippocrates* II; *Epidemics* 5, 1; 15, 8, Smith, *Hippocrates* VII.
45. *Prorrhetic* I 118, Potter, *Hippocrates* VIII.
46. *Prorrhetic* I 119, 117–124, Potter, *Hippocrates* VIII.
47. *On the Sacred Disease* 13, 19.
48. *Aphorisms* IV, 16, Jones, *Hippocrates* IV.
49. *Prognostic* XXI, Jones, *Hippocrates* II.
50. *Prorrhetic* II 30, Potter, *Hippocrates* VIII.
51. *Diseases* ii 19, Potter, *Hippocrates* V.
52. Jones, W. H. S., *Malaria and Greek History*, Manchester University Press, Manchester, UK, 1909, p. 8.

53. *Prorrhetic* I 96, 23, 24, 25, 55, 54, 90, 91, 94, Potter, *Hippocrates* VIII.
54. *Fleshes* 18, Potter, *Hippocrates* VIII.
55. *Prorrhetic* I 93, Potter, *Hippocrates* VIII.
56. *Prorrhetic* I 84, Potter, *Hippocrates* VIII.
57. *Internal Affections* 48, Potter, *Hippocrates* VI.
58. *Prorrhetic* II 28, Potter, *Hippocrates* VIII.
59. *Coan Prenotions* 56, Potter, *Hippocrates* IX; also *Internal Affections* 6, 14, Potter, *Hippocrates* VI.
60. *Prorrhetic* II 40, Potter, *Hippocrates* VIII.
61. *Internal Affections* 52, 53, 54, Potter, *Hippocrates* VI.
62. *Diseases* iii 12, 13, Potter, *Hippocrates* VI.
63. *Prorrhetic* I 44, Potter, *Hippocrates* VIII.

8

Ancient Greek Ideas of Cognition

The ancient Greek writers from Homer to Aristotle attempted to define the "powers that govern us," as Galen described it,[1] and part of that inquiry was the localization of mental function in the body. Concepts derived from observed behavior appeared in the Homeric mythopoetic tradition (seventh century) primarily as background motivation to explain the unknown causes of a man's experience. By the sixth century, the explanation of elementary perception and movement associated with a "mind" provided a target for inquiry among the pre-Socratic philosophers, and philosophical explanations dominated the understanding of cognition and of a "mind." The Hippocratic writers used the ideas of the pre-Socratic thinkers in their medical concepts but began to divest themselves from the philosophic interpretations. The philosophers in the fourth century expanded the idea of cognition to include consciousness, memory, understanding, thought, and imagination. The anatomical discoveries of the Hellenistic period established the data needed to correctly localize elementary perception and cognition to the brain. However, the stoics of the late third century BCE were targeted by Galen as ignoring the anatomical evidence and continuing to believe the heart was the organ of intellect and reason. The arguments for brain or heart as the origin of control ran parallel throughout much of ancient Greek thinking.

CHANGES IN THE IDEA OF COGNITION

The character, localization, and the activity of the mind along with the terminology used to describe it developed gradually, as we shall see, from the concrete notions of the archaic Greeks to the metaphysical constructions of mind–body function of Plato and the synthetic intelligence of Aristotle.[2]

The archaic understanding of cognition began with mythology that explained the creation and function of nature. As the discussion of the function of nature evolved, man was seen as the microcosm of the universe, allowing biology that reflected the phenomenon in man and represented an aspect of the universal. The medical conclusions about localization of the powers that govern were focused in either the heart or the head. The broader considerations about movement and the elementary senses of perception (vision, audition, touch, taste, and olfaction) provided the foundation for the ultimate exploration of the synthetic behavioral functions, such as sentience, selfhood, free will, memory, knowledge, moral values, and reason, that became a biophilosophic construct explicated by Plato, Aristotle, and other later philosophers.

The Greek philosophers and physicians had to conceive a physical or metaphysical process either in a bodily *locus* or in an external source; this process controlled motion, sensation, and conscious actions. That inquiry was diverse, convoluted, and spread over centuries. To escape the inevitable stew of ideas from ancient Greek thinkers that boils up in a review of the concept of mind, as much as possible this chapter focuses the discussion on the biologic aspect of localization, attempts to define the terms used about aspects of cognition, and establishes a chronology that preserves the historical context. The biology of cognition does not easily include the idea of a "soul" because it transcends anatomy. The soul was, however, a part of the understanding of behavior and thought, so we will attempt to find its place with the localization of cognition. The concept of a soul began in Homer as an impotent wraith and ended up as "The Soul," a synthetic center of man's humanity as well as the life force. The conundrum of soul–body function and location is central to the development

of ancient thinking about cognition, but the soul was never firmly localized in the body and was ultimately redefined so it became a philosophic construct without an anatomy. The mind–body conundrum was an active part of Greek thought, and it remains so today in the argument between the reductionist biologists and the current theistic designers.[3] Aristotle himself wrote: "To attain any assured knowledge about the soul is one of the most difficult things in the world."[4]

SOURCES OF INFORMATION

The information and attitudes of the pre-Socratic thinkers about cognition comes as *fragments*, which are quotations from the original authors used in works published much later than the originals. The ancient authors who used the quotations took them from copies of the original works that are now lost. Other bits of information come from paraphrases called *testimonia*, made by ancient writers based on the original works. The oldest testimonia and fragments come from papyrus scrolls from the second century BCE. The source of the pre-Socratic information has been collected in the "doxographical" literature, which contains the fragments and testimonia culled from later authors. The authors that provided the content of the doxography wrote as early as Plato and ranged into the sixth century CE (some later). The material comes from anthologies, encyclopedias, and summaries of the opinions of the philosophers. The validity of the fragments and testimonia in reflecting the original ideas of the philosopher is always suspect unless the ideas can be supported by well-authenticated extracts from the philosophers' own work. That dependency will temper our certainty at many points of the discussion.

MYTHOPOETIC HERITAGE

The unknown or inexplicable has been and still is explained by creating a supernatural interpretation that lies beyond men's power. To the archaic

Greeks represented in the Homeric epic poems, almost everything was mysterious, and the most awesome questions concerned the origin and structure of the earth, ocean, sun, and sky. Homer recognized supernatural power as the foundation and organization for all the events in nature. The archaic Greeks based their belief on their imagination, and they used the tradition of anthropomorphic gods to explain their lives and the universe.

The same reality of biology, physiology, and psychology that we know also faced the Homeric man, but he had no intellectual or scientific paradigm from which to devise an empiric, objective system to make sense of the natural world.[5] The archaic notions had to rely on "common sense," the bane of scientific discovery, to direct their ideas of cognitive function. The presence of the supernatural that was paramount in Homer persisted at least as a leitmotif throughout antiquity and beyond.[6] Indeed, there is still a theistic interpretation of the control of nature that mimics the Homeric pantheon in action but reduces the number of gods to one.

The Homeric poems (*Iliad* and *Odyssey*) describe the earliest Greek thinking to which we have access. Homeric man was convinced that nature and man were motivated by the gods, prevented by them, and influenced by them. Free will was an option despite the divine direction; man had to choose how his fate would apply. The Greeks could choose to follow the gods or not, but the actions of men were driven by the supernatural.[7] Superstition and magic explained the events of nature and the diseases of men, so that it was the gods who caused and cured disease. The *Iliad* opens with a plague put on the Greeks by Apollo because the god was unhappy with the behavior of Agamemnon, the Greek general. The malady was cured by the proper ritual supplication to Apollo. In the *Odyssey*, the cyclops was admonished by his friends to pray to the gods for help when he lamented that "no one" (the alias Odysseus gave) had caused his blindness.

The Homeric syntax did not have the capacity for generalizations, so the concepts were grounded in concrete imagery that indicated the way the mind worked.[8] The Homeric poems express concrete descriptions of complex behavior based on their observations by using a quantitative

vocabulary with analogy and simile.[9] The entities that contained vitality, emotion, and thought were located in the head or in the heart, and they defined the cognitive and emotional behavior of man. Thus begins the dichotomy of cognitive localization in man between head and heart.

INTELLIGENCE, AFFECT, AND CONSCIOUSNESS

Homer had little to say about the elementary senses, and there was no single localization in the body for the several entities that supported man's awareness or behavior; both head and heart were implicated. The *phrenes* was the substrate for understanding, perceiving, or knowing; affect was *thumos*; intelligence was *noos*; and the life force was *psyche*. Each was conceived as a material substance that came and went to allow functions we think of as mental (see Chapter 1).

The *phrenes* is the most localizable element of the mental apparatus that Homer used and is intimately associated with the heart, the breath, the respirations, and the thorax. *Phrenes* means midriff in the most literal sense, but it can mean the site of the mind or serve as a word implying the place of psychological passions, such as grief, joy, courage, fear, and others.[10] The word was probably used originally to describe the lungs or midriff because it is associated with verbs and prepositions that indicate a structure surrounding something: "But it hit him where the *phrenes* is packed around the beating heart" (*Iliad* XVI 481). Other good evidence for the lungs as the location for *phrenes* was developed by Onians.[11] Its attributes could have come from the concepts of breath as a part of the observed manifestation of mental activity. Phrenes is used in the broadest sense for describing the site of both emotional and cognitive activity and participates in matters of emotion, so it is not completely separate from them. It tends, however, to be used to describe wit, intelligence, and mind. Long after Homer in Hippocrates and Plato, *phrenes* takes back the meaning of the *midriff* or *diaphragm* so that the Homeric and the Attic vocabulary diverge in usage.

Thumos, a more diffuse entity, is derived from lexical roots that have the meanings of rapid action and to smoke or burn. There are cognate words in Greek and Sanskrit to support an underlying meaning of agitated activity. The term probably arose from the concrete observations of men in states of fear, grief, or anger who were clutched by abnormalities of breathing, probably hyperventilation; the term was used to indicate the very real idea of fear, grief, or anger that caused a man to express emotional responses such as sighing or panting. The emotional force of a man is his *thumos*, and it is the part of man's being that allows for his emotional activity and feeling. It was also seen as working in deliberative ways especially when a man was deciding important things in his own mind. The *phrenes* contains the *thumos*, and they coexisted simultaneously. *Phrenes* is used infrequently as the receptacle of desire (*Iliad* XI 89), while *thumos* is used frequently to indicate a desire or emotional need. They could both act in emotional and deliberative situations. The importance of the breath to the concepts of vitality, awareness, and consciousness combines these two terms to be nearly synonymous, but *phrenes* is a structural part and the *thumos* is a vaporous part. Moreover, *thumos* denotes an emotional aspect of cognition. Passion, willingness, eagerness, vulnerability, anger, and grief are all expressed by *thumos*, making it a general designation of emotional activity.[12] *Thumos* dissipates after death, but in life it resides with the *phrenes*.

The *noos*, the decision-making mind, was associated with the heart but was not absolutely fixed to an anatomic entity in Homer. It seems to represent a consolidation of the unorganized *thumos* into a more extended function that is an emotional activity of behavior without an anatomical locus; *noos* is to *thumos* as the current of a river is to the water.[13] As we will see, *noos* came to be used in a broader way to imply intelligence, without locus, that managed the universe, and then it took the role of the force behind the intelligence of man.

The concept of speech in Homer presaged the later use of air or breaths as a vehicle for cognition and perhaps as the basis for pathophysiology in some Hippocratic authors. The archaic Greek view understood spoken words as thoughts made tangible in the breath. The words were in

the air that carried them from one person's mouth to be grasped by the other person. So, the king of the Phaeacians can tell Odysseus: "If any word has been spoken that was harsh, may the storm winds straightaway *snatch it and bear it away*" (*Odyssey* viii 408–409). The words move and can be moved: "Wingéd words" is the Homeric epithet often used to indicate important statements. The word-as-breath concept also explains the peculiar epithet used when a character says something outrageous: "What word escapes the barrier of your teeth?" (*Iliad* IV 350). The site of breathing was obviously the chest, so that was a reasonable place to locate cognition for the archaic Greeks. The relationship of breath to thought and to intelligence was connected further linguistically by the Greeks. They used the perfect tense verb *pepnumai* to mean "have wisdom" (e.g., *Iliad* XXIV 377) or "to be conscious" (e.g., *Odyssey* x 405). As convincingly argued by Onians, *pepnumai* is cognate with *pneo* meaning to breathe, exhale, inhale.[14] So, the literal meaning of the perfect middle form is "to be in a state of having breath." The god's will "breathed" into a mortal could also manipulate the human mind. So, Penelope explains her plan to stall the suitors by weaving a never-finished cloth: "First some god breathed the thought in my mind (*phrenes*) to set up a great loom in my halls" (*Odyssey* xix.138). It was, literally to the Greeks, an inspiration.

Although mental function was not specifically associated with the brain in archaic thought, injuries to the head were described as causing alterations in mental status. The Homeric separation of cognition between head and heart was the concept from which the later philosophers and medical writers made their own choice regarding the location of the mind and cognition.[15]

HOMERIC SOUL

To the Homeric man, *psyche* ("soul") was the necessary element for being alive: It had little purpose but to reside diffusely within the body and to animate the person with life; it escaped at death, and it existed in Hades as the immortal, insensate wraith of the individual. The relationship

observed between loss of consciousness and death can be deduced from the Homeric description of each state.[16] Death occurred after the *psyche* left the body as a breath, but if one was revived after the exit of *psyche*, as in the fall and recovery of Sarpedon as discussed in Chapter 2, it was *thumos* that was said to revive.[17] The *psyche* and *thumos* were also the agents of episodes of rapture or swooning as when Andromache witnessed the dead body of Hector being dragged through the dust. She blacked out as her *psyche* left her; when she recovered, it was the *thumos* that came back (*Iliad* XXII 466–475).

The *psyche* has no emotional or intellectual function in Homer, and even in Hades it is nothing but an insubstantial representation of the previously living person, like a hologram of the individual; specifically, it is the head that is represented by the *psyche*. There are four instances of the phrase "passionless heads of the dead" in Hades; these illustrate the Homeric view of the congruency between the *psyche* and the head (*Odyssey* x 521, 536; xi 29, 49). The archaic separation of psyche from the other mental elements was further defined by the depiction of Tiresias in Hades. He was the sole inhabitant of the Underworld who retained understanding and wisdom postmortem: "His mind (*phrenes*) abides steadfast and even in death, to him has been granted insight (*noos*) that he alone should have understanding, but the others flit around as shadows" (*Odyssey* x 490–495).

The "soul" in archaic thought was a diffuse phantom of the person and was the factor that allowed a person to be alive. The more specific cognitive functions were assigned to other terms, which vaguely resided in both head and heart. The Homeric *psyche* is perhaps the most elusive tradition in the panoply of mental elements for us to conceive because it morphed into a specific metaphysical concept in the later Greek notions of cognition. Today, we tend to associate the soul with some sort of a divine aspect of our own being. That was not a part of the Homeric concept. In the next phase of inquiry, the explanation of cognition progressed so that the *psyche* begins to accumulate the functions of *thumos* and *phrenes*. The new notion of *psyche*, the vital source of life that can also provide the ordinary feelings of life, was expressed by Pindar, a poet, in the early fifth century.

Pindar[18] used *psyche* as the traditional Homeric shadow that follows death to Hades,[19] but in other places he expanded the use to indicate *psyche* as managing the feelings and behavior of men on Earth.[20] He also used *psyche* as keeping the soul pure in *either* this or the next world.[21] Pindar signaled the developing elaboration of *psyche* and the consolidation of mental function that had begun in Homer between thoracic and cranial entities. The anatomical site of cognition of *psyche* in the head and the *phrenes* in the chest then became fused in the later concepts of the mind into one site or the other. Now, we can follow the evolution of the localization from the chest to the head.

PRE-SOCRATIC PHILOSOPHERS BEGIN TO DEFINE NATURE

During the sixth century, the pre-Socratic natural philosophers sidestepped the pagan anthropomorphism of Homer and began to replace the supernatural organization of nature with the assumption that the universe is understandable without supernatural explanation, despite the unexpected mutability of natural phenomena.[22] The Greeks began to see nature as independent of the gods, and they conceived nature as a predictable, physical balance that followed an immanent mechanism of the universe.[23] The pre-Socratic philosophers postulated immortal, fundamental physical substances extended in space as the *arche* (later *phusis*) or basis of the universe. Aristotle reported a summary of their materialistic belief: "For there must be some natural material either one or several from which the others are born while that one is preserved."[24] The pre-Socratic Greek concept of a material universe developed over many years, proceeding parallel to the gods, and defined specific material origins to explain nature and life.

Thales of Miletus (fl. 585), named by Aristotle as the earliest natural philosopher, chose water as the primary substance on which the universe was based.[25] Anaximander, a younger contemporary, postulated a metaphysical substance that was unknown, unlimited, and indestructible, "the

indefinite" (*to apeiron*) as the basic source of all other things.[26] He began the first attempts to rationally explain the origin of the universe from a moist primordial slime.

Anaximenes of Miletus (fl. 546) chose air or "breath" as the primordial substance and explained changes seen in nature as the rarefaction and condensation of the air.[27] He was described as having a notion of a universal "breath soul" that reflected the archaic concepts of breath as a life force we found in Homer. Aetius, a doxographer from the second century BCE whose work comes to us from later sources, offered a testimonia from Anaximenes that seemed to describe a "soul," but the text is likely corrupt: "As our soul, being air, holds us together and controls us, so does breath and air enclose the whole world."[28] Further elaboration on the breath theme persisted as the carrier of life and health in the physiology of the Hippocratic physicians. We need to be clear now, however, that the notion of *psyche* or soul mentioned in the pre-Socratics (as delivered to us by the later doxographers) was not yet the actionable soul of Plato or Aristotle and certainly was not the soul as it became understood in the early Christian era.

The parallel between the origin and the operation of the universe and the nature of man himself continued as the concept of soul developed.[29] Heraclitus (early fifth century) posited fire as the primal substance and emphasized change (or motion from one state to another) as a regular and balanced part of nature that had to be included in the worldview. He added *logos*, a "reckoning or a plan," which lay behind changes in nature and was part of the *psyche*; the "plan" behind the soul was a deep structure, infinite, but not extended in space so it was separate from the material of the body.[30] Here the soul is a force rather than a wraith as we found in Homer. The *logos* allowed change to be manifest regularly, just as the changes were observed in a burning log. The *logos* implied a director for the actions of the world, and eventually it would follow that there should be a director to manage the perceptions and cognition of man. There needed to be a definition for the central, consolidating substance for order and function in the universe and a structure for control in the human body.

Anaxagoras, also early in the fifth century, proposed the notion of a primary, unmixed, and pure substance he called *noos* as the controlling principle of the motion in the universe and for man.[31] *Noos* is translated conveniently but misleadingly as "mind," which tends to obscure its material definition. According to Plutarch, Anaxagoras was among the earliest to separate the divine from the natural phenomena.[32] Anaxagoras struggled to develop a concept of a controlling material that was beyond physical dimensions, but he could not escape the fact that reality was defined by extension in space. Therefore, he developed a duality of an unmixed pure substance working in the background of the separate material world.[33] He constructed mind as a fine structure inherent in the universe but remaining unmixed with it. The unifying substantial mind allowed the changes of nature but preserved the unity behind it. He had come up with a material dualism between mind and matter. Censorinus (third century CE) said that Anaxagoras held the brain to be the source of all senses.[34] Plato later amplified the duality to define the universe.[35]

EARLY LOCALIZATION OF COGNITIVE CONTROL

Alcmaeon of Croton (500–450) identified the brain as an important locus for control of perception.[36] He was a Pythagorean and believed that most influences in man came in pairs. He seemed to separate perception from intelligence and recognized that the brain was connected to the eyes and therefore to vision and to the other senses.[37] He wrote mostly about medicine but was said to have written a book about natural philosophy.[38] His book *On Natural Science* is lost, and our information is based on fragments and testimonia. He is quoted as having expressed the idea that in man "the controller is in the brain."[39] There is a bit of a problem with the authenticity of that passage from the doxographer because the word *hegemon* used for the "controller" is characteristic for expressing stoic dogma, a later use, that would not be part of Alcmaeon's vocabulary. Alcmaeon also described passages from the eyes to the brain, perhaps based on animal dissection, and he proposed that the brain received perceptions from

the eye, sound from the ear, and other sensations from the other sense organs. He also attributed thought to the brain. Alcmaeon considered the brain as at least the site of perception and perhaps as the locus of cognition.

A more overt and theatrical presentation of perception and its control mechanism came with Empedocles (495–435), who developed the pluralistic notion of four primary elements (earth, air, fire, water) from which the universe was constructed. Influenced also by the Pythagoreans and probably trained in medicine, Empedocles conceived the four elements as interacting in response to the universal motivation of "love" and "strife," which may be easier for us to consider as the affinity and division of the humors.[40] He believed that natural phenomena were the result of chance combinations of the humors and that the outcomes that were most fit survived.[41] His concept might tempt one to suspect an evolutionary thought that was completely absent in Greek thinking. Empedocles thought that perception occurred when the emanations of physical objects came through pores into the body as a mixture of the elements that they contained. Like things perceive like things because they shared the compatible pores and effluents. For example, the eye cannot perceive auditory stimuli because each had different elemental aspects.[42] He conceived of the sense of sight as coming from "fire" within the eye and from the emanations of fire from objects, coming in through the pupil. He described the eyeball as a container holding the fire and that it was designed to prevent the fire from extinguishing, much like a glass put over a candle to prevent the wind from blowing it out. The fire itself penetrated the "linens" of the eyeball and created the pupil, which was a fine matrix so fire could not pass through.[43] There is nothing in the extant sources from Empedocles that divulges his view on the synthetic aspect of perception or a consolidating mechanism of the mind. He seemed to equate the senses with reason and intelligence but developed no central force to combine or keep together the energies or elements of the mind.[44] He believed, like Homer, that the senses, mind, and control of the person were in the blood and control emanated from the heart: "The heart dwells in the sea of blood which surges back and forth, where, especially, there is what men call

thought; for the blood around men's heart is thought."[45] Blood was his choice because it was considered the best blend of the four elements, and he supposed that the blood carried the breath to the other parts.

The anatomy, physiology and physical location of the processes of cognition were a minor concern to most of the pre-Socratic Greek philosophers even though they thought carefully about how perception worked generally. The early authors split in their vague localization of the mind because both the head and the heart had a rich tradition to promote its case. The notion of the breath as the key to physiology became the focal point for explanation of disease and supported the later ideas for localization of the mental functions around the lungs and heart.

THE BREATH AND THORACIC LOCALIZATION OF COGNITION AND EMOTION

Diogenes of Apollonia (fl. 440–430), perhaps a physician,[46] was an eclectic thinker who used air as the single element behind nature and man. Air and the breath allowed perception and provided the intelligence of the universe. Diogenes looked back at Anaximenes's notion concerning the air and deepened the concepts to allow the air to be a "divine" element that rarefied and changed so that everything else developed from it. He thought the surrounding air was the source of intelligence and of life itself.[47] Air could motivate the obvious changes in the world that Heraclitus had defined as a key to understanding nature. Diogenes also described the vascular array through the body that was important in transferring the breath to the body. The later medical writers, including the author of *On the Sacred Disease*, reflected this breath through vessels in their explanation of pathophysiology.[48] Breathing and the breath were observed to be essential for living beings, and the effects of air (winds) were experienced directly so that breath was an easy pick as the prime substance for the universe and of man.

Diogenes named the brain as a site for some mental function, but it was not the central controller of the mental status. He described hearing as the

result of the air inside the ear being moved by the air outside and spreading to the brain. Likewise, the sense of smell came from the air around the brain.[49] The air was carried by the blood, which altered it, and the result provided affective states like pleasure or pain. He implied that cognition based on the breath was diffusely organized throughout the body, but the brain was just one example of where the air might be active.[50]

The case for the thorax and heart as the center of control of cognition was also supported because anger, mirth, grief, and other emotions affected the tempo and quality of breathing. Speech was observed to come from the respiratory apparatus, and the words, created of the breath, were obviously the concepts and thoughts of the person. The Homeric concepts of speech as breath were well known, so the idea was not alien. It followed therefore that the center of language, and therefore of thought, must reside with the breath and in the thorax. The premier organ in the thorax was the heart, and its role as the center of cognition grew out of its putative relationship to breathing. The association of the breath with emotion and the localization of the *phrenes* to the thorax and lungs also provided a strong bias for the localization of perception and mind in the heart and thorax.

THE HEAD AS THE CENTER OF MENTAL AND PROCREATIVE FUNCTIONS

Although Greek thinking recognized the thorax, heart, and lungs as obviously related to mental status, the head was also the source of important functions. Even in the prehistoric Stone Age, the head was regarded as a vital structure in man's anatomy. The head and its contents were seen as the site for the identity of the individual and for procreative life function. Archaeological finds revealed prehistoric burial sites with special enclosures for the head, the only part that was especially protected at burial; at many sites, the skull was the only part remaining. Shrines have been found consisting of animal skulls, and there is Stone Age cave art that emphasizes the head in its depictions of animals.[51]

In the earliest cultures, the head was linked to the genitals and was considered the source of the semen, analogous to the seed pod on the top of plants. There was a notion that the orgasmic sensation was perceived at least in part, in the head. Moreover, the development of a beard on a boy's face was nearly coincident with hair in the pubic region, so they saw a relationship between the head and the reproductive potential.[52] The ideas of connection of head to genitals were male oriented, so the early figures of women showed tiny heads but huge breasts and hips, an example is the famous relic the Venus of Willendorf. The Greeks, since Homer, had considered the head (and brain) to contain the immortal *psyche* as well as the generative semen, although they did not necessarily see it as the seat of cognitive function.[53]

The *psyche*, located in the head, was the aspect of man that allowed the person to persist in Hades. The semen was the part that allowed mankind to persist on Earth. *Psyche* began as the agent of "being alive," not as an element of the mental apparatus or as involved in emotion or perception. The word *psyche* comes from the word *psyzein*, which means "to blow," and *psyche* is associated with the breath, so when one dies the *psyche* is emitted as a vapor as described previously. The natural vent of the *psyche* and the reproductive seed was the genitals.[54] The head was also an important focus of one's humanity, and it served the Greeks as a focus for honor in an athletic contest, when it was garlanded and was regarded as a sacred symbol by which to swear an oath.[55]

Even late in the classical period, the head was seen as part of the reproductive system and the brain, spinal cord, and cerebrospinal fluid as the source of semen.[56] The notion was prehistoric,[57] but the connection may explain the presence of the Herms, statues showing Hermes's head atop a pillar with a phallus below it, erected as funerary or border markers in fifth-century Athens and other Greek cities. Hermes represented generative powers; he was the giver of increase and wealth, and he carried the *psyche* to the underworld, hence his epithet "conductor of souls."[58] The symbolism of the Herms is clear because it was the penis and the head that represented immortality both of the individual and of the race. The head did not have the obvious respiratory activity that was evident

in the movement of air in the chest, but as Greek thinking became more abstract, the head was considered to participate in the air as much as and even more than the lungs.

THE HIPPOCRATIC CONCEPT OF MENTAL FUNCTION AND LOCALIZATION

The Hippocratic physicians were well acquainted with the thought and tradition of the natural philosophers about the body of man and the universe, but the Hippocratic physicians emphasized a biologic method as the basis for understanding the human body in health or disease. They attempted to explain the organs and their function as well as to provide ways to keep healthy. They disparaged the reliance on a single universal substance to explain medical experience, although they retained the idea of essential elements or humors that defined the body.

The Hippocratic physicians conceived physiology as an amalgam of pre-Socratic ideas blended with their own observations of their patients. Health was assumed to be a balance of the elements in the body, and disease was an imbalance. They conceived the balances and imbalances of bodily processes or disease states as the key to prognosis and treatment. Their writings revealed their observations and their technical skills, but they had no experimental techniques to test their hypotheses or valid anatomic or physiologic information on which to base their assumptions. The understanding of mental function came from their overall experience and a concocted physiology. Their remarkable conclusions about many medical conditions, including the identification of the brain as the central source for human function, attests to the power of their clinical skill in interpreting their observations.

Despite the dearth of any real medical information, the Hippocratic authors who expressed an opinion, except the author of *Heart,* identified the brain as the organ for speech, consciousness, and life.[59] The treatise *On the Sacred Disease* (epilepsy) defined the role of the brain in cognition and described its pathophysiology:

> Men ought to know that from the brain and from the brain only arise our pleasures, joys, laughter, and jests, as well as our sorrows, pains, griefs and tears. Through it, in particular, we think, see, hear, and distinguish the ugly from the beautiful, the good from the bad, the pleasant from the unpleasant, in some cases using custom as a test, in others perceiving them from their utility.[60]

The author identified the brain as the most powerful organ and defined it as the interpreter of the sensory world and as the messenger to consciousness. He expanded the role of the brain in the pathophysiology of disease:

> I believe that the brain is the most powerful organ in man. If it is healthy, it interprets for us the influence of the air, and it is the air which produces cognition. The eyes, the ears, the tongue, the hands and the feet accomplish the things which the brain conceives for the brain controls cognition in the whole body as it shares the air. The brain is the one organ that informs the consciousness. For whenever a man draws his breath, it travels first to the brain, and from there the air disperses into the rest of the body, after it sets down its own essence in the brain and whatever it may have of intelligence and knowledge. The air would lose its perfect value if it went to the body first and later to the brain, having spent its discerning power in the flesh and the vessels and coming, mixed with the juices from the flesh and the blood, warmed and impure into the brain.[61]

The author rejected the notion that the seat of consciousness resided in the diaphragm (or the lungs). He asserted that "diseases that attack (the brain) are the most acute, most serious, most fatal, and the hardest for the inexperienced to judge of." We hear the echo of Alcmaeon, who thought the brain was the *hegimonikon*, the commander, of the body in his rendition of cognition. The author continued to explain the maladies

of the brain using the theory of the breaths as the key to the underlying pathophysiology.

The Hippocratic physicians moved medical thought toward rational, if imperfect, explanations of physiology and disease. They dismissed sacerdotal explanations, and the ones who chose to speak of it were convinced that cognition and all other mental function resided in the brain. They provided an explicit localization of the cognitive functions in the brain, and their method of observation and validated experience in clinical situations lifted medicine to a near science but their efforts were buried by the next overriding voice in the development of Greek thought.

PLATO USES PHILOSOPHY TO CONJURE PHYSIOLOGY

Plato (427–347) solidified the dualism conceived by Anaxagoras to create a dialectical system based on a reality (the forms) that is beyond perception, thereby excluding observation as a way to derive the truth of nature. He negated the validity of experimental understanding of nature or biology in favor of abstract analysis and philosophical conjecture. Plato's contribution to the localization of cognitive function was tangential to his philosophic and ethical interests.

In the *Phaedo*, Socrates explained his concept of nature as he dismissed observation as a means to understand ultimate reality.

> When I was young, Cebes, I was tremendously eager for the kind of wisdom they call investigation of nature. . . . I was always unsettling myself with such questions as these: . . . Is it the blood, or air, or fire by which we think? Or is it none of these and does the brain furnish the sensations of hearing and sight and smell, and do memory and opinion arise from these, and does knowledge come from memory and opinion in a state of rest? . . . Finally I made up my mind that I was by nature totally unfitted for this kind of investigation.[62]

Socrates resolved that one cannot know the first principles, the *ideas* behind the perceptions, by studying the bogus information available through physical perception.

Plato did not answer, or even seriously address, our questions about anatomy and physiology because to him they were irrelevant to the true understanding of the basis of the universe and the nature of man. He created a *psyche* that had no localization and was prior to any perception or motion. The soul was not anatomic but universal and not an object of medical manipulation. This was a new "postulate" to explain human behavior that the author of *Ancient Medicine* warned would undermine the validated facts of medicine. Plato dismissed the product of "science" as a derivative of the superficial observations of the individual so it produced knowledge devoid of universal validity.[63] That distance allowed Plato to ignore what passed for science and to create his own medical model in which the senses and movement were subsidiary to an "understanding intelligence" (the soul) that was beyond man and was the only pure reality. This was not theism because there was no activity of the gods but rather a different organizing entity altogether.

The *Timeaus*, one of his late dialogues, revealed Plato's attitudes toward the mind–body interface where he discussed the localization of the aspects of cognition as far as they fit with his worldview, and described the world soul that is behind a dual universe. The universe was directed by a rational creator that was independent of the physical world and previous to it, which allowed true value to exist. Anything that was not part of this background rationality (being) was inherently prone to change, falseness, misunderstanding, and imperfection (becoming). The background reality was not a material but rather an indeterminable being through which all else got its definition.

Plato was interested in the basis of moral and rational activity, and the bits of anatomy he strung together are a convenience to his philosophical notions rather than a serious explanation of the biologic facts. Nonetheless, he used a biologic metaphor to explain the basis of the true world of ideas and explained the soul of a man as a microcosm of the "world soul," the basis of the rational intelligence in the universe. He specified a demiurge

that created the universe both through reason and by necessity. The world intelligence, the rational thought and knowledge of things, *psyche*, was a construct that mixed the constant and inconstant, sameness and difference; it allowed existence to have meaning, allowed order to prevail, and good to dominate. It contained the world body, and it was prior to the world's body itself. This construction of *psyche* was a giant step from the passive concept from Homer and diametrically opposed to the way the Hippocratic physicians saw nature.

Plato describe the soul as the aspect of a human being that "causes it to live and gives it the power to breathe the air and be revitalized, and when this revitalization fails, the body dies and is finished."[64] The external intelligence or the world soul was internalized in man to form the soul that ruled the body of a man and allowed him to be sentient. Plato parsed three aspects of the soul: rationality or intelligence, emotional activity, and the physical appetites. A man's soul, said Plato, fulfilled a metaphysical duty and consolidated all the aspects of physiology, health, and life. The soul was the ultimate part of the human being that could make deliberations, choose good from evil, and act as the director of the body. The rational soul managed the emotions and the appetites. It was separate from the body, but was is embedded in the human organism as the element of being that was part of the universe itself.[65] The rational soul was located in the head, separate from the mortal soul, which was in the thorax and below. The baser aspect ruled the appetites and was located in the belly. Anger, fear, and other emotions came from the spirited part in the heart and lungs.[66]

Plato knew nothing about anatomy or physiology, but that did not prevent him from concocting suppositions about the body's activity. He mounted a teleologic argument to explain the body parts and was lucky to name the head as the center of rationality, intelligence, and decision, although he had no interest in the facts of biology. He described the assembly of the body, and his explanation was indeed an example of "intelligent design":

> Copying the round shape of the universe, [the gods] confined the two divine revolutions in a spherical body, the head, as we now call

> it, which is the most divine part of us and master over all the rest. To this the gods gave the whole body, when they had assembled it, for its service, insuring that it possessed all the motions that were possible. So that the head would not roll along all sorts of heights and hollows on the ground, and be unable to climb up the one or to climb out of the other, they gave the head a body as a vehicle for ease of travel; that is why the body is elongated and grew four limbs that can be stretched out or bent, the god designing it thus for its traveling. Clinging and supporting itself with these limbs, the body is able to make its way through every region, carrying at the top of us the habitation of the most divine and sacred part.[67]

His was a better guess than that of Aristotle at least. He made a strict connection between body and mind so that physical and mental disease were connected. His explanation of sensation was based on the elements of fire, earth, air, and water. The circuits of the soul ran in man's body like a river, neither controlling it nor being controlled, but they produced movement, which was the basis of vitality.[68] The senses were informed by changes in the external environment and registered through the body of man to the soul. Plato explained perception as a result of change in the four elements of the universe as they affected the body and soul. He thought that perceptions were combined in some central way, but he waffled regarding a single organ of the *psyche*. Perceptions came as appearances relative to the individual and were recorded without prejudice. True and false perceptions were recorded equally by the scribe of the soul as in a book. He also conjured a cognitive "painter," which produced the illustrations of the perceptions recorded in the body that form opinion, belief, and awareness of the future.[69]

Hearing was "inflicted by air on the brain,"[70] but it seemed to go on to the liver, where it became sound. Plato's mythology of cognition was not much focused on the carnal anatomy, so he did not explain it systematically. Plato did provide, however, a location for soul in a short description of the central nervous system. He defined the *marrow* contained in the spinal cord and brain as a mixture of "seeds of every sort for every mortal

kind." The creator "implanted and made fast therein the several kinds of souls." The portion that contained the divine soul was in the head and was called the "brain." The rest of the spinal marrow extended to the lower body "as if from anchors, he put forth bonds to fasten all the soul." The body was constructed around the marrow that anchored the soul.[71]

In the *Theaetus* (185d), Plato said there was no single organ of mind, although he declared the ancient idea that the head (and the brain) were the source of the semen and contained the divine part of the aspects of *psyche*.[72] He saw the need for a synthetic apparatus to allow the perceptions to be integrated into higher cortical functions such as memory, imagination, and consciousness and so was engaged in trying to establish a central integration for perceptions that created the second-order cognitive functions. He said that "it would be a very strange thing, I must say, if there were a number of perceptions sitting inside us as if we were Wooden Horses, and there were not some single form, soul or whatever one ought to call it, to which all these converge—something with which, through those things, as if they were instruments, we perceive all that is perceptible."[73] To provide the synthesis of perception to the consciousness of man he used his fallback overriding universal thought form (i.e. soul) rather than a paradigm based on perception itself.[74]

Plato's rudimentary use of medical information not only reflected his priority of metaphysical thinking but also came from the absolute lack of scientific method available at the time. Philosophy still ruled science. The dearth of empiric thinking and the absence of techniques for experimentation blocked any scientific discovery until the late Middle Ages and Renaissance. Plato was perfectly comfortable to conjure an anatomy and physiology using internal logic for a creation myth rather than by confirming a hypothesis with data. Plato's medical deductions were diminished by the next major Greek thinker, Aristotle, who used his observation of nature to create a biology and an analytic system that was the template for our inductive reasoning. Nonetheless, Plato's philosophy remained as a major influence that was carried on by the Neoplatonist and Christian writers, who ultimately replaced the the physical approach to medicine with myth and mystery in the later part of antiquity.[75]

ARISTOTLE GENERALIZED THE SOUL AND PUT THE COGNITIVE FACULTIES IN THE HEART

Aristotle (384–322) produced a systematic study of biology and psychology that was cherished by subsequent generations until Galen eclipsed it with better data. His works were important for his own ideas and as a major source for the ideas of the previous thinkers whose work he reviewed. He developed his ideas using observation and crude experimentation, which was, as we would define it now, devoid of a modern "scientific" method. Aristotle constructed his view of cognition using his notions of the elementary perceptions and their need to be integrated into higher cognitive function. Like Plato, Aristotle thought there was a special, interactive, and reciprocal communication between the body, the mind (or "cognition in general"), and the emotions. However, he took Plato's overarching theory and set it in a more empirically friendly structure with ideas that used verifiable observations.

Aristotle rejected the concrete materialism of the pre-Socratic philosophers but kept a universal basis of nature. He accepted the role of philosophy as the basis of medicine and as the first principals of understanding man and his place in nature.[76] He realized that it was not enough to describe perceptions as related to the sense organs but that simultaneous perceptions coming via several organs had to fit with the synthesis of higher-order awareness. The synthesis required him to find a processor to integrate all the senses and to synthesize the data, allowing discrimination, comparison, direction of motion, and sense of time and space. He had to account for the ability of the individual to realize the act of perception and to be conscious of a sight, sound, or taste. Imagination, memory, and dreaming all had to come from a process that was beyond the sense organs themselves. The pre-Socratics had passed by this integration conundrum with background ideas of mind or soul. Plato had conjured a metaphysical "intelligence" that lay behind the body's synthesis of perceptions. Aristotle found a "common sensibility" (*sensus communis*) embedded in the body, a part of the soul in philosophical terms, that allowed the synthetic consciousness of the perceptions: the knowing

that we perceive things. The *sensus communis* allowed consciousness, memory, and the other higher cortical functions. For that task, Aristotle chose the heart.[77]

In *The Soul*, Aristotle envisioned the soul, which contained the common sensibility, as having two abilities: to discriminate perceptions and to originate movement. The soul allowed individuals to be potentially active and distinguished them from entities that were not alive and had no potential to be active. The soul was a part of the body and not separable from it:

> The soul cannot be without a body, while it cannot be a body; it is not a body but something relative to a body. That is why it is in a body, and a body of a definite kind. . . . Soul is an actuality or account of something that possesses a potentiality of having a soul.[78]

The functions of the soul were blunted by aging but only because the organ of cognition and perception became defective. The underlying integrity of the mind remained intact, just as the inherent ability to see remained despite failure of one eye. Aristotle saw the relationship between the mind and body as that of actuality and potentiality, the sense and the sensible, the mind and the intelligible. The soul was the hand that grasped the tool; it was the motive force, and a failure in function was once removed from the true function in the soul.[79]

Aristotle's comments in the treatise *On Memory* explained his view of a commonsense faculty that discriminated, in a time frame, between fresh perception and the perception from previous experience. Memory was separate from intellect, and it depended on a persisting perception that was harbored within the function of the imagination. The commonsense faculty could consolidate the persistent perception with the current perception to allow a memory of things past. The memory failed in the elderly because the soul was not strong enough to keep the impression made on it by experience, as when the wax was too soft to hold the impression from a seal. In the young, the soul was too unyielding or unstable to receive the imprint, so the impression was not made, as if the wax was too hard or washed out.[80]

From his observation and dissection of animals, Aristotle came to describe the anatomy of the brain that he saw as important but not as the site for the common sensibility. "The brain of all animals," he said in *History of Animals*, "is bloodless, devoid of veins and cold to the touch."[81] "The purpose of the brain," he said in *Parts of Animals*, "is no less than the preservation of the whole body."[82] Then: "Nature has contrived the brain as a counterpoise to the region of the heart with its contained heat and given it to animals to moderate the latter, combining in it properties of earth and water. . . . The brain tempers the heat and seething of the heart."[83] The brain acted as a radiator to cool the body's heat. He stated explicitly that the heart contained the origin of the senses, the emotions, and thought.[84]

Although he believed that the brain, and more likely the meninges with their abundant vessels, played an intermediate role in synthetic cognition, he rejected it as the key organ for several reasons. First, the brain seemed insensible to mechanical stimulation,[85] and he noticed that there were certain invertebrates that responded to stimuli without a brain.[86] The brain appeared bloodless, so it could hardly be expected to be an organ concerned with sensation.[87] Last, he failed to recognize any connections between the brain and sense organs.[88]Aristotle felt there were positive reasons the heart was the better choice. The vessels of the heart connected directly to the organs of touch and taste, and the other sense organs were also associated with blood vessels.[89] The heart was the center of the vascular system, which carried the vital heat.[90] The heart was the first organ in the human to move and the last to stop at death[91]; its motion changed with pain and pleasure. He also noted that loss of blood caused insensibility, and the heart, positioned in the center of the body, seemed appropriate for its purpose.

Aristotle also commented that the heart had abundant fibers which indicated its importance in allowing movement of the body. Aristotle assumed that all of the fibrous structures of the body, *neura,* came from the heart and were connectors within the body.[92] The abundant fibers in the heart that fooled Aristotle were the chordae tendineae, which Galen ruthlessly pointed out 500 years later. Galen also savaged Aristotle for

being wrong in bypassing the brain for the heart as the *hegemonikon* of the senses. Aristotle was driven by his observations in nature, and it is an irony that using the best science yet to be practiced he was so wrong about the seat of cognition, whereas Plato, who merely made up his data, was right. The Hellenistic physicians, who dissected human cadavers, settled the question, and the brain was finally revealed as the organ of cognition in the third century.

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9

The Separation of the Nerves from Other Fibers

The ancient physicians and philosophers, before the Hellenistic era, did not recognize any of the fibers in the body as "nerves," but they certainly recognized the need to transport information from the external world and register it in the body to allow perception and movement. The need to establish communication within the body and to allow response and reaction finally led to the identification of nerves in the third century BCE. Solmsen charted the course of the inquiry to establish connections from the body to a central controller through the passage of the humors.[1] We can also look at the changing use of the words describing the fibers themselves, which ultimately were understood to carry connections to the central organ that controlled perception and movement.

The organ controlling function in the body was proposed to be located either in the heart or the brain, as discussed in Chapter 8. The reasoning assumed that the center of control would be an organ or element that was widely connected with the rest of the body. Fibers with different anatomical forms were observed in the body and understood as structural elements. Their role as the physical connections within the body was not known, although the vital elements of nature were thought to pass through channels, passages, or pores to connect the organs of perception

with a control center. The passages had to conform with the speculated vital element that provided the motive and perceptive force; blood was thought to establish connections because it was distributed throughout the body through the vessels.

The natural elements—air, fire, water, and earth—were examples of influences distributed in the body through whatever channels there were. The air (*pneuma*), as we will see, became a favorite element that could transmit action and perception. The Greeks speculated a physiology of control despite the dearth of observed data on which to organize a theory. It was fully acceptable to fit whatever observations they might have into a theory of the body's function without evidence, as a *logo theoreta*.[2]

Over the centuries, observations by physicians slowly provided understanding of the anatomy that allowed them to separate the mainly structural fibers of the body into two types: the *ines* and the *neura*. The *neura* finally was the word used to mean the nerves once the concept of connection was established. We can follow the usage of the two Greek words, *ines* and *neura*, which begin as meaning merely "fibers," as they changed so that the connections in the body were expressed and the nerves were recognized. The ultimate realization of motor and sensory nerves occurred when human dissection and anatomy guided the Hellenistic physicians to the answers. The story starts, however, with Homer.

ARCHAIC GREEK IDEAS OF THE FIBERS

The *Iliad* and the *Odyssey* are the primary sources of archaic Greek life, the earliest period described by texts in Greek history, as discussed in Chapter 1. They were written in the eighth or seventh century, but they reflect traditions of an earlier era transmitted through oral narratives sung for generations.[3] We will not find our idea of the "nerve" in Homer because the concept was unknown, there was no sense of passages, and there was no concept of a central controller. In fact, there was no overt medical data in the epics, but they introduced the terms for fibers, *neura* and *ines*, and established the earliest meanings. Our word *neurology* and

other cognates that indicate the nervous system are derived from the Greek word *neura*.

Homer used *neura* in one place to indicate the tendons of the foot (*Iliad* XVI 316).[4] It appeared once more, meaning the "sinews of the ox," as a fiber used in making a bowstring (*Iliad* IV 122). Another cognate word means "bowstring," which was in fact made of the fibers of animal bodies. The term *ines* appears frequently in the epics to indicate fibers in the body and is an older word witnessed by its originally having the digamma. It had a more anatomic use than *neura* and meant "tendons" or "sinews" observed in animals and in man. The description of Apollo protecting the cadaver of Hector from the heat of the sun illustrates: Apollo clouded the sky "lest the might of the sun shrivel his flesh round about on his sinews (*ines*) and limbs" (*Iliad* XXIII 191). The *ines* were the fibers that held the bones, joints, and other structures together and were also associated with the fibrous back of the neck of the ox: Its singular accusative form *inion* was used to mean the occipital protuberance where the tendons attached at the nape of the neck, a usage that remains in our anatomy as "inion." The term *ines* was used more frequently in the epics in a different way to mean "strength," "force," or "power" of the body. In this usage, the digamma becomes obvious in the Latin cognate *vis*, meaning force or power (*Iliad* 23.720 and 21.356).

Neither *ines* nor *neura* contained the idea of a conduit or connection with any other part of the body in Homer. The archaic usage was further illustrated by the description of the insubstantiality of the dead in Hades, as explained to Odysseus by the ghost of his mother: "For the sinews no longer hold together the flesh and the bones" (*Odyssey* xi, 219). A medieval scholiast added a comment in the manuscript on this passage:

> They mention these things here because the chords (*neura*) as far as perception and motion are organs that maintain the whole basis of a person. There is the flesh and the chords, and the flesh becomes settled and releases from the chords. And the chords provide the resistence of a person. On account of this it is said "for no longer do the fibers hold the flesh and bones."[5]

This comment was obviously a reflection of the biology at the time of the scribe; indeed, he replaced *ines* with his "modern" term *neura*. The structural usage in the *Odyssey* was carried forward in later authors to describe the attachment of the joints and to indicate the strength of the body, but the two words separate in their specific connotations, as we will see.

THE PRE-SOCRATICS

Between the sixth and the fifth centuries, the pre-Socratic philosophers developed the theoretical paradigms that later developed into a physiology of sensation and motion. They understood the universe and its function as derived from a single material source. Water was the universal substance proposed early on by Thales (fl. 585), but other substances were postulated by the subsequent philosophers. The tendons, ducts, and nerves were observed by the pre-Socratic observers, but they saw no obvious differences among them, they did not assign specific function to them, and they were called *ines* or *neura* mostly based on their size. The fibers were not considered connections but rather supports for the body. The *ines* and *neura* were also considered to be nearly equivalent terms by the ancient lexicographers. Apollonius in the *Lexicon Homericum*[6] said the *ines* were the *neura* stretched through the body. The *Suda*, a medieval Greek encyclopedia, equated *ines* and *neura*. Erotian, who wrote a Hippocratic glossary, defined the word *ines* as sometimes the same as *neura* or as the fibers making up the *neura*. A connection to the controlling organ had to be defined, but there were no observations that clarified routes to a central organ of control. The ideas of connections grew from the theories of physiology developed by the pre-Socratic philosophers based on notions of the primal material of nature that did not necessarily need a physically observable transit system.

Empedocles (495–435 BCE) theorized that there were four elements—fire, earth, air, and water—that mixed to form all other things depending on the proportions of each element. The force behind the combining was "love" and "strife" (frag. 17/25).[7] He said we were to trust the

information from the senses that come to us by "any way there is a channel to the understanding" (frag. 3/14).[8] The channel (*poros*) was the route of sensory particles that acted in unison with human reason. Empedocles provided a detailed explanation of how the senses worked using particles interacting on the body.[9] He named the blood, distributed throughout the body, as the key place where the elements were balanced, and he determined that the heart and its blood were the center of perception and motion. No connecting fibers were needed because the blood and vessels provided the communication. At least he was aware that there needed to be connections via the blood vessels among the areas of the body to allow them to work in harmony.

At about the same time, Alcmaeon of Croton (mid-fifth century BCE) suggested the brain, rather than the heart, was the center for consolidating sensation and motion. He also postulated passages, *poros*, that carried the sensation to the brain. The perceptions of sight, hearing, and smell were collated in the brain, and there was a synthetic function that could allow perceptions to cause action. The brain was like a "switchboard" to distribute the various messages that came in from the outside; he did not seem to recognize independent activity of the brain that modified or transformed the incoming sensations.[10] When the passages were blocked, the sensation and function were disrupted. He allegedly identified such connections from the eyes to the brain, probably by observing the optic nerves during animal butchery. The sources reporting Alcmaeon's ideas are suspect, so there is a suspicion that the description of his thoughts might have been confounded with those of the later anatomists.[11]

Diogenes of Appolonia (fl. 440–430) also conceived of passages to allow air, his choice for the primal substance, to move along to the brain, heart, and other parts of the body. Diogenes also made the brain important in the interpretation of the sensations but allowed the heart a place for the mixing and balancing of internal and external air. Diogenes thought that the blood vessels were the likely connectors through which air could pass. There was no role of the blood itself except to inhabit the vessels where air was transmitted.[12]

Democritus (fl. 430) believed that the universe consisted of infinite specific atoms that were in a configuration with spaces between them that allowed passages. The atoms of the external world that penetrated the body through the spaces, depending on their shape, interacted with other atoms to cause effects. The atoms from outside the body would penetrate the sense organs and go deeper in the body as well. The connections were diffuse without a specific target, but the atoms themselves were specific in their effect. He postulated that sensations were transmitted in the body so that the whole body was infiltrated with the atoms that made up the universe, including those that were the cause of sensation and motion. He said that to ensure good vision, "the ducts connected to the eye [need] be straight and dry so that they may perfectly conform to the entering imprints."[13] Democritus also allowed for specific "soul atoms" that could account for the control of motion and act as the source of bodily activity. He did not see a "center" and never made it clear if brain or heart was involved. Thus, Democritus constructed an idea of both a causative mechanism with the atoms and an interpretive one by specific soul atoms.[14]

The pre-Socratic thinkers did not construe the fibers in the body as connections for sensation or motion, but they were busy in establishing the need and mechanism for transmission of external input to influence the function of the body. They were also in search of the place through which the information was made usable.

HIPPOCRATES

The terms *ines* and *neura* appear with good descriptions throughout the Hippocratic texts to indicate the types of tendons and fibers identified around a joint or in the muscles. The term *neura* was also used by some authors to designate cords associated with the male genitals, perhaps from the external appearance of the urethra in the ventral aspect of the phallus. The head and the brain were thought to contain or to generate the semen, and *neura* were conceived to extend from the head, and indeed through the whole body, to the genitals.[15,16] By now, *ines* were small fine

fibers as in muscle, and the *neura* were generally larger, thicker structures. The terms were used as distinct entities in the recurrent phrase: *ostea kai neura kai ines*, "The bone and the chords and the fibers."[17] So, the two words were used to distinguish separate structures. The function of *ines* and *neura* was structural in Hippocratic thought. When the *neura* were cut in the top of the wrist, the hand dropped, pulled by the tendons below and vice versa.[18] In another text, *ines* were used in a list of items through which the ill person sensed his illness; this did not imply a nervous function but merely a general sensitivity of the body during illness.[19] The *ines* could also be used to designate small fibers in the body or linear streaks of blood.[20] *Neura* and *ines* appeared together in a discussion of the joints, so we can see how they were used specifically by the author of *On the Places in Man*:

> The cords (*neura*) exert pressure on the joints, and they are present over the whole body. They have the greatest strength and are invariably thickest in the parts of the body where the fleshy parts are least. The whole body is quite full of chords; around the face and head however, there are no chords, but instead fibers (*ines*) similar to cords, narrower and more rounded, midway between bone and muscle: they are the hollow cords.[21]

Here, we see the distinction and the concept of hollow cords through which something may pass. The author also described the nature of disease in the cords and made the distinction between vessels and cords: He said that all the vessels communicated and flowed into each other; he continued:

> Any disease that arises from the vessels is easier than one that arises from the cords (*neura*), for it flows away in the vessels with the moisture, and does not remain fixed. The home of the vessels is in the moisture in the tissues. Cords are on the other hand dry and lack a lumen, and they grow next to the bone; they receive most of their nutriment from the bone and also some from the tissue. Cords

> are in color and strength midway between bone and tissue; they are moister than bone and more fleshy, but drier than tissue and more ossified. Any disease that enters the cords is severe and settles in one place, and it is difficult to drive out. The most frequent examples are tetanus and similar diseases, as the result of which trembling seizes the body and makes it shake.[22]

The Hippocratic idea of transmission of signals from sense organ to the central controller was described in *On the Sacred Disease* as coming through the blood vessels. The Hippocratic author followed Diogenes in the use of air as the transmission element, and he saw the brain as the crucial organ of control. The central role of somatic function was defined specifically in the Hippocratic text *On the Sacred Disease*; however, the author did not define how the vessels and organs were connected: "Speechlessness occurs when the phlegm suddenly enters into the vessels. It shuts out the air keeping it from the brain, the open vessels and the viscera and also it interferes with the breathing."[23] The underlying physiology involves the passage of the external air via the blood vessels in the transmission but there is no connection described to the brain. The Hippocratic author of *On the Sacred Disease* believed that there was an external air that allowed the functions of perception and motion in the body, but he did not identify the fibers as the connections.

As the concepts of perception and motion became more defined, the separation between the mental and the physical parts of man became more explicit. The connections remained diffuse and undefined in Hippocrates. Thinking, sensation, and motion were derived from outside influences allowing life itself and were part of the body's function. The notion of soul was not yet called out to provide a controller or to define a man's life.[24]

PLATO

Plato (427–347 BCE) created an unequivocal dualism that identified a non-physiological soul separate but in communication with the body. The soul

managed the life force, emotional functions, and the rational mind, which was the central understanding facility that managed the physical senses. His physiology, quite scant, appeared in the *Timeaus*[25] and was adapted from Empedocles, the Pythagoreans, and according to Galen, from Hippocrates. There was no attempt to create an idea of anatomic or physiologic function, so his concepts were driven by his philosophical theories. He split aspects of the soul or the synthetic center between the brain, heart, and liver. He did not recognize anatomical links between the soul and the rest of the body but decided that particles that were derived from the elements fire, air, earth, and water entered the body and acted to stimulate motion of one degree or another. The degree of motion determined the nature of the function. The sense organs were full of fire and air, so they were very sensitive, but the bone was mostly derived from earth, so it was insensitive. The particles were distributed throughout the body, but Plato was not clear how. He seemed to suggest it was the blood that did the job, at least for hearing,[26] and the vessels were the narrow channels through which the particles moved.[27] Plato elaborated the concept of a mind and soul, separate from, but connected to the body, by which the perceptions, and from which the motion, of the body must ultimately be linked. Perception and sensation were parts of the soul. We find *ines* and *neura* used by Plato in the traditional sense only. He used *neura* as structural elements in the joints. He used *ines* to mean the streaks in the clotting blood.

ARISTOTLE

Aristotle (384–322 BCE) defined the mind as the highest aspect of the soul, but "mind" had no physiology, was mostly independent of the body, and had no definite body location. He placed the movement and perception aspects of the soul in the heart, but he renounced the blood as the conduit of perception or movement because it had no active sensation itself.[28] It was *pneuma*, the breath, that Aristotle chose as the means by which movement occurred, and although more ambiguously, it was also the substrate through which sensations came into awareness.[29] The

motion of the body came from psychic reaction (e.g., fear) or perception that changed the innate air, which changed the heat of the body and thus allowed the limbs to act.[30] He identified perception as the air going into the nose and ear, full of the innate air, connecting via the blood vessels deeper within. The connection came with the air moving through the body with the heart as the central organ by which the air worked.

There were no connective channels described in his scheme of perception and motion. Aristotle identified *neura* in the heart[31] and believed that all the sinews in the body originated from the heart.[32] He considered the *neura* to be primarily associated with the joints,[33] using the traditional idea. He directly stated there were no *neura* in the head.[34] He made an observation that cutting a sinew caused only a feeling of numbness in the area in which the sinew was located, so it could not be very widespread.[35] He used the word *ines* to indicate fibers intermediate between the *neura* and the vessels.[36] He also used the term to mean the streaks in the dried blood itself, similar to Plato's use. Aristotle did not recognize the nerves, but he did dispose of the old idea that the blood was the means of communication with the center of perception and motion. Unlike the Hippocratic author of *On the Sacred Disease,* Aristotle saw the *pneuma* not as coming from outside the body but as innate to the body and controlling all voluntary movement internally. Aristotle had no need to postulate direct connections between the body and the controller because the innate air was pervasive in the whole body.

Aristotle's influence was supreme, and the physicians who followed him in the early third century BCE took up his idea of the *pneuma* but fell back to believe that the blood was the connection between the body and the heart. That construct allowed more concrete postulation of the means of connection between the controller and the activity of perception and motion in the later thinkers.

PRAXAGORAS

Praxagoras (fl. 300), one of the most famous doctors in antiquity, separated arteries from veins and considered the arteries as the pathways for

the *pneuma* and the veins the pathway for blood. He also taught that the arteries narrowed as they proceeded distally and the lumen collapsed; he called the distal part of the artery the *neura* and mentioned those fibers to explain the motion of the fingers, an idea rejected later by Galen.[37] He followed Aristotle in thinking that the heart was the center of cognition and source of perception and motion. Galen savaged him along with Aristotle for thinking that the nerves had anything to do with the heart: "They were themselves completely blind or conversed with blind men when they wrote on the origin of the nerves."[38] The Hellenistic physicians Erasistratus and Herophilus finally figured it out in the middle of the third century BCE.

THE HELLENISTIC DISCOVERY

The Ptolemaic dynasty, which was created after the death of Alexander the Great, established an intellectual headquarters in Alexandria, Egypt. Among the many scientists, scholars, and literati who worked in Alexandria, there were two physicians, Herophilus and Erasistratus (both floruit third century), whose ideas have survived through testimonia and a few fragments found in later authors. Their anatomical insights came from the dissection of animals and human cadavers. They may also have practiced vivisection on human beings supplied from the prisons. It was their dissections that established the anatomy of nerves.

Herophilus, a student of Praxagoras, realized the fibrous structures that connected the brain, muscles, and sense organs were independent of the arteries and were specific connectors. He fit this discovery into the long inquiry seeking a way to connect the senses and motor activity to a central controlling organ. The concepts of pores, passages, and channels seen and unseen that connected the body to the mind were usurped by the physical fibers seen between the body and the brain. Herophilus evidently assigned the actual motion or perception to the nerves themselves, rather than making them the connectors between brain and receptor, allowing the brain to act and react.[39] Galen told us that Herophilus used

Praxagoras's ideas of a distributed network for communication between body and the controller but he replaced the arteries with his newfound nerves. Galen, in discussing tremor, accused Herophilus of mistaking the nerves as the seat of pathology when in fact it was the disruption of *pneuma* that caused the trouble:

> There is necessarily no one affected place in tremors, and here I find fault with Praxagoras and Herophilus—with the former for saying that tremor is an affection of the arteries, with Herophilus for being so eager to show that tremor is always associated with the nerves. Praxagoras is further from the truth; but Herophilus erred in attributing to the structures (i.e., instruments) an illness that is actually of the motive faculty. He understood correctly that it is the nerves, not the arteries, which serve the voluntary motions. But since the body of the nerves is not itself the cause of motion, but is only the instrument, and since the cause of motion is the motive faculty moving through the nerves, I find fault with him for not having distinguished faculty from instrument. For if he had made such a distinction, he would have straightway recognized that actions will suffer not only because of affections of the instruments, but also because of affections of the body's faculties. Thus, in dead men neither nerves or muscles experience anything such as Herophilus and Praxagoras think they experience, yet every motion has left them the instant the soul does, and muscles and nerves are instruments of the soul.[40]

Galen compared the origin of motion to music played on an instrument like the flute. The origin of the music was the musician, the flute was the instrument through which the musician crafted the song. A deficit in the music could come from a problem with the craftsman or the instrument:

> The craftsman and artificer of voluntary motion in animal life is the faculty governing the animal, while the instruments are the nerves and muscles. Therefore lack of motion and incorrect motion are either due to affection of the instruments or of the faculty using these

> instruments. Hence, palpitations, spasms, and paralyses are injuries of the instruments, while tremors are affections of the weakened faculty.[41]

Galen was 400 years better equipped to have a more precise understanding of the role of the nerves, but Herophilus had associated the nerves with the "principle of action," found the brain and spinal cord as the origin of the nerves, and even identified the cerebellum as the most important part of the brain for movement. Thus, as Solmsen suggested, it is likely that Herophilus maintained the idea of *pneuma* as operative in the motor nerves even though he was not as clear about it as Galen demanded. Indeed, Herophilus described the sensory nerves as paths for the *pneuma*, in fact the specific *perception-breath* had to pass to the brain.[42] He identified the motor nerves and associated them with the brain as the controlling organ. He lumped all the fibrous structures together as *neura* and made the connecting nerves a subgroup.

Erasistratus, a younger contemporary of Herophilus, carried the investigation of the nerves further and finally eclipsed the work of Herophilus. The attribution to Herophilus and Erasistratus of the discovery of the motor and the sensory nerves in the third century BCE came from Rufus of Ephesus in a text written in the first century CE, 300 years after the discovery:

> The nerve is a simple solid body, the cause of voluntary motion, but difficult to perceive in dissection. According to Erasistratus and Herophilus there are nerves capable of sensation, but according to Asclepiades not at all. According to Erasistratus there are two kinds of nerves, sensory and motor nerves; the beginnings of the sensory nerves which are hollow, you can find in the meninges [sc. of the brain], and those of the motor nerves in the cerebrum and the cerebellum. According to Herophilus on the other hand, the *neura* that make voluntary motion possible have their origin in the cerebrum and the spinal marrow, and some grow from bone to

bone, others from muscle to muscle, and some also bind together the joints.[43]

EPIC AND MODERN

The Hellenistic poets active in Alexandria in the third century were at the cutting edge of the avant-garde in combining the old literary forms with the newest trends. In his *Argonautica,* Apollonius constructed a work patterned after the Homeric epics but filled with contemporary (and other) allusions to enrich the story for the Hellenistic readers. Theocritus, another Hellenistic poet of the early third century who was from Sicily, not Alexandria, wrote bucolic poems using traditional images and common themes. The use of the word *ines* by the two poets illustrates the old and the new definition of the term as it appeared in the third-century literature.

Theocritus described an old fisherman as he gathered his net in exertion: "Even though he is grey [haired], the fibers (*ines*) of his neck swelled everywhere."[44] Here, the word was used traditionally, but a medieval scholion has been added to the manuscript that explained the word more precisely. It tells us that "*ines* are the *neura* (fibers) which closely follow the vessels; a son was also called *inis* from them for the semen seemed to come from these parts."[45] In this case, not only did Theocritus use *ines* in the traditional sense to indicate strength but also evidently the readers could associate an even more basic and ancient connotation of reproductive potency with it.

Apollonius used *ines* twice in the *Argonautica*. He described the hunter Idmon going along the river where a boar gnashes his thigh, severing it through the sinews (*ines*) and the bone. Here, he used *ines* in the traditional sense of tendon and structural tissue associated with the bone.[46] Further in the story, Apollonius wrote one of the most dramatic scenes in the world's literature with a different meaning for the word. Medea burned with her love for Jason and her anxiety for his safety. She was agonizing over her desire to help him escape death, help that required her to

thwart her father and murder her brother. In this passage, the term *ines* was rendered by most translators as "fine nerves" based on the context and the supposition that Apollonius was inserting a clever reference to the latest medical discovery from the Hellenistic physicians. The word had not meant nerves before. Here are the key lines rendered literally from the Greek[47]:

> And internally a constant pain wore upon her, [a pain] smouldering through her body and *moving through the fine nerves and even beneath the lowest nape of her head, where the most grievous pain enters* whenever the indefatigable forces of love let grief fall upon the mind.

The assumption that Apollonius really was referencing nerves is generally accepted, but doubt was expressed by some scholars. The passage was written almost entirely in epic vocabulary and with Homeric constructions. The word *ines* was a typical archaic word, and the current third-century word for nerve was, in fact, *neura*, which would be completely out of place in an epic-style poem. There are no other examples up to the third century of the word *ines* used in a context that implies conduction of sensation. The passage, however, depends heavily on epic forms and vocabulary. For example, Apollonius used an archaic term, *prapides*, meaning mind or understanding, for *phrenes*, the standard term in third-century texts. He used *inion* (for the back of her neck) in the traditional sense immediately after using *ines* in the "modern" sense to mean nerves. The argument in favor of the new meaning rested on the fact that he described the pain (i.e., sensation) as *moving about* the fine nerves. Despite the ambiguity, it is not hard to believe that the passage heralds the new meaning as nerves and that the poet was announcing his awareness of the nerves to his audience. This is not an unusual tactic for any author and quite usual for a Hellenistic poet. Thus, the context allows us to see the intrusion of a new idea into the old vocabulary. *Ines* did not carry on as the major term for nerve despite Apollonius, but *neura* changed its meaning to denote the connection between the brain and body. Its Latin cognate gives us our word *nerve* as well as *neurology*.

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10

The Hellenistic Pursuit of Neuroanatomy

The Hellenistic era, 323 to 31 BCE, began when Alexander the Great died in Babylon in 323 BCE. Greece itself became a historical footnote over the ensuing years, and the most stable fragment of the royal empire of Alexander was in Egypt. The generals and the family of Alexander were in contention for more land and loot than they were assigned at his death; indeed, they fought among themselves for the sovereign power of it all. Although a semblance of a single royal empire remained for a few decades, there was left only a ghost of an empire that haunted the individual rulers.[1]

Ptolemy I (Soter) had seen the futility of trying to take the whole empire from the others during the initial struggle for power, and he accepted Egypt and the neighboring regions as his share without attempting to take more. He established his successful Egyptian dynasty,[2] which lasted until the Romans eroded it, ending it in 30 BCE. Alexandria was a Greek haven in Egypt and became an important center for science and scholarship. The Hellenistic age was marked by dynastic autocracy in public affairs and commercial or intellectual disengagement in private life, unlike the Greek traditions in previous times.[3] There is an attitude among some who have appraised Hellenistic history that there was a stagnation

of culture and a general decline in the quality of intellectual life during the era. This notion assumes the grandeur of fifth-century Greece as the pinnacle of Greek civilization and reflects the latter part of the Hellenistic era. The general assessment must oscillate between favorable and unfavorable opinion because the Hellenistic period was so long, its activities so complex, and the early evidence so scant.[4] But, Alexandria, during the first 100 years of the Ptolemaic dynasty under the rule of Ptolemy I Soter (323–283); Ptolemy II Philadelphus (283–282 to 246); and Ptolemy III Euergetes (246–221) became the center of literature, philology, mathematics, technology, science, and medicine. The penetration of Macedonian-Greek ideas into Egyptian culture provided a creative environment conducive to innovation, and it fostered a departure from traditional ways of Greek thinking. The sciences became more specialized, and many intellectual pursuits were funded by the kings, allowing new opportunities for research.[5] Greek power waned in Alexandria after the third century BCE, and the overt effort to increase Egyptian cultural values and to expel[6] Greek intellectuals gelded the momentum of Alexandrine innovation. However, during most of the third century, Alexandria produced extraordinary erudition, including the understanding of the human body and the "discovery" of the nervous system. Herophilus of Chalcedon and Erasistratus of Ceos, physicians active in the middle of the third century, played the prominent role in nervous system research. Their books are lost, but we have testimonia and fragments that transmit their ideas. Both physicians made observations, while working as physicians, to establish the anatomy of the nervous system. They were aided by the king and were also connected to the literary leaders and the intellectual community at Alexandria.

THE COMMUNITY OF SCHOLARS

Ptolemy Soter, a proud Macedonian, came to power in Egypt with the sense of exploration inherited from his experiences with Alexander and with the sense of philosophy from Plato's academy and Aristotle's lyceum.

Soter established a temple to the muses in Alexandria, the Alexandrian Museum, which was a research center that ultimately grew into the focal point of Alexandrine scholarship and literature. The museum and its famous library were funded by the court and supported local and visiting scholars, poets, and scientists. Unlike the earlier classical models, the museum was not a school but a research institute funded by the kings rather than by the scholars themselves.[7] The Ptolemies of the third century saw the museum and library as a way to make themselves famous and bring prestige to their court. They attracted smart people from all over the world whose presence enhanced the stature of the city and their court.[8] The engineers built amazing gadgets,[9] and the poets wrote avant-garde verse. Ptolemy II hosted the most talented people in the world, and they were respected as patrons by them. A glimpse of the attitude fostered by the Ptolemaic court appeared in Theocritus's *Idyll* XVII, in which he lauds Ptolemy II for his noble birth, his vast lands, his power, and, although he outweighs all monarchs in wealth, "the interpreters of the muses sing praise of Ptolemy for his good works."[10] In *Idyll* XIV, Theocritus has Thyonichus, a man-on-the-street character from another country, describe Ptolemy II to his friend as "one of the best of men, well meaning, a lover of learning, attractive, delightful through and through, recognizing his friends and more important his enemies. As befits a King, he gives much too many not denying those who seek [his help]."[11] Callimachus extolled the king at the end of the *Hymn to Zeus*[12] for his efficiency in managing the state. Praise for the king was routine among the poets, and as the poems circulated, so did the positive image of the king and his largesse. This kowtowing seems the same as we now practice when academic medicine plays at the court of wealthy donors.

The museum was the intellectual center of Alexandria, and there is indication that the participants were very much aware of each other's work. Financial support from the court varied greatly under the first three Ptolemies, and many scholars associated with the museum received nothing. Callimachus hinted at the variability of patronage in the *Hymn to Zeus*, saying that Zeus "gives to all [the leaders] but not in equal measure."[13] Then, at the end of the *Hymn,* he stated flatly what he

wanted as necessary support for achievement: "Resource without virtue does not elevate a man to excel, nor does virtue without resources; grant us both the resources and the virtue."[14]

It seems likely that the medical research was not fully financed by the Ptolemies. Despite the evidence for sharing of ideas between the doctors and the literary men at the museum, the medical researchers were probably not directly associated with the museum.[15] A poet was perhaps hard-pressed to live on the sale of his intellectual output, except his sales to the court. On the other hand, the engineers, architects, and physicians could sell their skills in the private sector and earn a living without financial dependence on the court.

Doctors in general, and even those well known in Alexandria, suffered a negative reputation for their limited skill and marginal success with patients. There was at least a wariness of their incompetence, as was documented by the epigrams of the Greek anthology collected in the first century BCE and later. The following is from the group of epigrams concerning physicians:

> The physician Alexis purged five patients at one time with enemas, the five seemed sick and he anointed the five again. And for all of them there was one night, one medicine, one coffin-maker, one tomb, one Hades, one lamentation.[16]

> Physicians indeed could be overbearing, as Plato seemed to imply in *The Symposium,* where he depicted the physician Eryximachus as an arrogant, pedantic medical professor, although careful reading helps to resuscitate a streak of acceptance in the character.[17] Plato provided Eryximachus as a stereotype that we can recognize today of the most vociferous of the "opinion leaders" that strut their medical knowledge on almost any subject to attract attention in various media for their employers. Physicians probably had a better reputation among their day-to-day patients seeking help because the patients needed the treatments and had little knowledge about their

efficacy. Celsus told us that there was a well-accepted hierarchy of notable physicians who had begun with philosophy and developed the art of medicine, which led to the Alexandrine achievement[18]:

> We find that many who professed philosophy became expert in medicine, the most celebrated being Pythagoras, Empedocles and Democritus. But it was, as some believe, a pupil of the last, Hippocrates of Cos, a man first and foremost worthy to be remembered, notable both for professional skill and for eloquence, who separated this branch of learning [medicine] from the study of philosophy. After him, Diocles of Carystus, next Praxagoras and Chrysippus, then Herophilus and Erasistratus, so practiced this art that they made advances even towards various methods of treatment.

There is no extant evidence of medical research being done at the museum,[19] although there is an inscription from Delos dating from the second century BCE identifying a man called Chrysermus of Alexandria as *Exegete*, supervisor over physicians and administrator at the museum.[20] Of course, his role at the museum is not clear, and there is nothing to indicate that he did any more than act as a "surgeon general." The honored positions that we know at the museum went to the literary men and the philologists rather than to the scientists. The site of the human dissections and vivisections may have been in the museum rooms, and the museum might have provided a facade of credibility, with priests and the court to veil the whiff of taboo that was likely associated with the practice.[21]

The medical practitioners were perhaps, as is still true in universities today, extramurally funded and separate from the core group of scholars at the museum itself. There may have been, however, some undocumented support for the sciences because there was scientific activity if not in the museum itself at least in the vicinity. The medical men, who charged for their services, needed little more than a few extra square feet and a few simple instruments for their research—no need for a cyclotron in those days. Thus, in the third century the physicians worked quite easily independent of financial support from the court but, as will become clear, were hugely dependent on the Ptolemaic court in its influence on

the social environment, and they were dependent on nonmonetary help in their research.

MEDICAL AND LITERARY ASSOCIATIONS

Although perhaps separate from the museum, the medical aspects of Alexandrian scholarship did not go unnoticed by the Hellenistic literati. Theocritus,[22] who was from Syracuse but worked in Alexandria at least for part of his life,[23] addressed a physician, Nicias, who may have known or worked with Erasistratus.[24] Nicias appears in two other of his poems and may have been from Cos. In *Idyll* XI, Nicias was described as "fortunately being a physician and well regarded by the muses."[25] Theocritus used a medical allusion to let his lovelorn singer say that the songs he sang were just as good as any doctor to cure his sad rejection by his would-be girlfriend, Galatea. The Hellenistic poets had at least a superficial interest in the medical world and included it in their own works.

Encouraged by the ferment of discovery, the poets used many innovations, one of which was to twist the literary tradition by introducing details of third-century medicine into their works. Callimachus, who is the epitome of the Alexandrine poet–scholar, illustrated his awareness of medical progress and used it to energize an old story, looking back to the *Odyssey* with an unexpected medical fact. In *Hymn* III, he described the cyclops' eye "beneath their brow like a shield of *four* fold hide for size."[26] The shields in epic times traditionally had seven layers, but Callimachus seemed to know that current medical research had determined that the eyeball had four layers.[27] He did this again in *Hymn* IV when he described the mythic birth of Apollo in terms that reflected the contemporary Hellenistic sitting position for childbirth rather than repeating the standing position in the Homeric *Hymn,* which was his ancient source.[28] He kept the myth intact despite the benefit of the contemporary technique, but he also added the realism of a clinical detail not found in the older account by giving Leto a prolonged labor.[29] Again, Callimachus revealed his interest and understanding of current trends in medicine when he

described the love between Acontius and Cydippe and he described Cydippe's illness as the "disease which we erroneously call sacred."[30] He conjoined the idea of the rejection of the sacred with the superstition to ritually wish the malady off to wild animals. As he described it: "She was seized by the disease which we wish onto the wild goats and which we falsely call the sacred disease."[31] The divine etiology of disease was a well-known medical notion dismissed by the Hippocratic writers and generally by the Hellenistic physicians in their reaction to the faith healers who practiced temple medicine. Again, the Hellenistic penchant of mixing the contemporary with the traditional enlivened a poem.

Another example of the influence of the medical database on the literary imagery of the Hellenistic poets came in the *Argonautica*, written by Apollonius of Rhodes (see Chapter 9). He described the emotional turmoil of Medea over the safety of Jason, first in terms of her heart quivering in her breast, then he continued to describe her emotional state as moving through her nerves. The image of the nerves used to express emotional reaction may be poetic license but it also signals an awareness of the anatomy that was being discovered.[32,33] Emotional imagery remains even today expressed as something "heartfelt" despite our understanding of the actual cardiac physiology being merely collateral to emotional activity, so we cannot assign much scientific weight to Appollonius's description.

PREEMPTING THE GREEK TABOO AGAINST DISSECTION

Lifting the taboo against dissection of human cadavers occurred because of the prevailing political and social attitude that, just as the literary temperament in Alexandria, was on the cutting edge. The Ptolemies ruled absolutely and developed a central bureaucracy and monetary policy that kept the country rich at least until the middle of the second century. The high degree of attachment to Greek culture separated Alexandria from the rest of Egypt. The Greeks coexisted with the Egyptians rather than merging their cultures; in fact, the Ptolemies took on the cultures of both,

so that it could be said that up in Egypt (upstream of the Nile or geographically South), they played the Pharaoh, and down in Alexandria they were Hellenistic.[34] They were called Pharaoh in Memphis, which automatically made them gods, but in Alexandria, the Greek idea of apotheosis came from an individual and personal phenomenon rather than from a dynastic title. The Ptolemies, however, were quite willing to compromise Greek tradition and to disregard Greek sensibility based on the needs of the political situation. In almost all the aspects of the government, there were dual Greek and Egyptian cultural precedents.[35]

Perhaps the prime example of the compromise of cultures was the unblinking practice of incest, which the Ptolemies accepted and which the Egyptians, unlike the Greeks, regarded as standard for the royals. It was expedient to intermarry to preserve the power of the dynasty, and using the Egyptian precedent, Ptolemy II Philadelphus married his sister Arsinoe II. There is little to tell us how the Alexandrine Greeks felt about their coexistence with the Egyptian customs, but Sotades, a Greek poet, wrote a poem about the royal marriage in which he said rather bluntly to the king: "You're thrusting your prick into an unholy hole."[36] He was, as we may say, run out of town for his verse. Theocritus gave the culture clash a sycophant's spin when he described the king's marriage: "His fine noble spouse who makes him a better wife than ever embraced a bridegroom under any roof, seeing that she cherishes with her whole heart brother and husband in one."[37]

The compromise of traditional Greek (and indeed Egyptian) constraints on behavior in third-century Alexandria helped advance medical knowledge because it fostered a way of thinking to neutralize the Greek taboo about dissecting human bodies. The Ptolemies liberalized the attitude and directly aided and abetted the physicians in their anatomical pursuits; that was patronage worth more than money to the doctors. Human dissection had not been done previously by the Greeks because of the magical religious concepts, veneration of the dead, and dread of the corpse.[38] To the Greeks, dissection of human bodies seemed a desecration worthy only for a heinous enemy.[39] The traditional religious and moral arguments were no doubt buttressed by the logistical and aesthetic

problems with preserving the cadaver for dissection. Nevertheless, the ambitious Ptolemaic court, influenced by the eager researchers, yielded to break with Greek tradition. Alexandria was "modern" enough to supersede established values, if pushed, and there was an existing precedent from the native Egyptian practices.[40] Egyptians opened bodies for mummification without compunction, but there was no precedent for the systematic examination of the corpses. The Egyptian priests who eviscerated bodies (in a limited way) were subjected to scorn and driven off (at least ritually) because it was believed that to apply force to the body of a person from one's own race was anathema.[41] Nevertheless, it seems the priestly class that dealt with cadavers provided authority enough in Alexandria to allow the jump from mummification to dissection.

Celsus told us that the Hellenistic physicians not only dissected cadavers but also operated on living persons, death row prisoners, given to them by the king:

> It becomes necessary to lay open the bodies of the dead and to scrutinize their viscera and intestines. They [dogmatists] hold that Herophilus and Erasistratus did this in the best way by far when they laid open men while alive; criminals received out of prison from the kings and while still breathing observed parts which beforehand nature had concealed. . . . Nor is it, as most people say, cruel that in the execution of criminals, and only a few of them, we should seek remedies for innocent people of all future ages.[42]

The validity of Celsus's testimony, especially for vivisection, has been questioned, perhaps because it is a practice that does not sit well with current sensibilities or in fact with some ancient commentators. Tertullian, an early Christian author who lived just before Galen, expressed his disdain through a translation made by another churchman, Peter Holmes, done in 1870.[43]

> There is that Herophilus, the well-known surgeon, or as I may almost call him, butcher, who cut up no end of persons (Tertullian said

> *sexcentos*), in order to investigate the secrets of nature, who ruthlessly handled human creatures to discover [their form and make]: I have my doubts whether he succeeded in clearly exploring all the internal parts of their structure, since death itself changes and disturbs the natural functions of life, especially when the death is not a natural one, but such as must cause irregularity and error amidst the very processes of dissection.[44]

The Hellenistic period was not one concerned with human rights or universal compassion. It was routine to torture slaves to extract testimony and to treat them in ways we would not allow for animals (or would not admit to allowing). According to Galen, prisoners in Pergamon were used to test new poisons.[45] Von Staden, in his definitive book on Herophilus,[46] reviewed the arguments for and against Celsus's testimony of vivisection in third-century Alexandria. It seems likely that the Hellenistic physicians Herophilus and Erasistratus[47] in the third century BCE dissected human cadavers for the first time and probably operated on living persons with the sanction of the royal court, which made condemned criminals available for vivisection. This window of opportunity open to Herophilus and Erasistratus allowed them to make the observations in human beings that had been impossible in the past. The tenacity of orthodox Greek proscriptions and the Egyptian reluctance for dissection and vivisection of human beings helped to close the door on the procedures. The "traditional values" against desecration of the cadaver must have reemerged, and the anti-intellectual and anti-Greek movement supported by Ptolemy VIII changed the parameters ruling anatomic inquiry. The empiric school of medicine, developed in the third century in Alexandria, actively ridiculed invasive investigation into causes of disease. The strengthening of the Egyptian influence on culture, paradoxically, because it had provided the original excuse, exerted its negative influence on the acceptability of human dissection. Dissection and vivisection seemed to have ended by the late third century BCE or early second century, and Hellenistic anatomy was not superseded until the resumption of dissection in the Renaissance.[48]

THE BEGINNING OF NEUROANATOMY

There are fragments to support the anatomic descriptions of nervous structures by dissection of animals as early as the middle of the fifth century with Alcaemon, who may have described the optic nerves. The source for the information, Chalcidius, however, did not clearly separate Alcaemon's work from that of Herophilus, leaving in question the actual observation by Alcaemon rather than his mere speculation about the optic nerves.[49] Other early texts had described the brain in animals superficially, but none in detail.[50] Modern anatomy, however, began in the middle of the third century BCE, and neuroanatomy developed with it. Praxagoras of Cos hinted at the role of the nerves, but his student, Herophilus, moved it forward, and Erasistratus, slightly younger than Herophilus, brought it to its ancient limit.[51]

Praxagoras of Cos was reputed to have descended from Asclepius. He was associated with the Hippocratic physicians; Galen listed him in the league of the most famous physicians probably active at the end of the fourth century.[52] He was a major authority in medical matters and was the teacher of other famous doctors, the best known being Herophilus. He believed that health and disease came from the humors that were in the body and expanded the four Hippocratic humors to explain all that was in "accordance with nature and all that is contrary to nature."[53] His concept included the function of generated heat, which could alter the humors and precipitate illness. The origin of the heat was somewhat unclear from Galen[54] but may have been from the food itself in Praxagoras, while in Aristotle it was thought to be an innate heat. Galen described his view of the concept:

> Now in reference to the genesis of the humors, I do not know that one could add anything wiser than what has been said by Hippocrates, Aristotle, Praxagoras, Phylotimus and many others among the Ancients. These men demonstrated that when the nutriment becomes altered in the veins by the innate heat, blood is produced when it [the heat] is in moderation, and the other humors are produced when it is not in proper proportion. And all the observed facts agree with this argument. Thus,

> those articles of food which are by nature warmer are more productive of bile, while those which are colder produce more phlegm. Similarly of the periods of life, those which are naturally warmer tend more to bile, and the colder more to phlegm. Of occupations also, localities and seasons, and, above all, of nature themselves, the colder are more phlegmatic, and the warmer more bilious. . . . Also the diseases which are primary and most generic are four in number, and differ from each other in warmth, cold, dryness and moisture.[55]

Praxagoras was important for his ideas concerning the identification of the arteries and the veins. He subscribed to the traditional theory of *pneuma* as the physiologic mechanism for movement and perception and as the basis of pathophysiology. Praxagoras did not subscribe to the idea of an innate heat, and he required an external source for the heat and for the *pneuma*, which was the ultimate source of soul function. The digestion of food was the source of the blood, the heat, and it caused a bubbling to occur that provided air, which was incorporated in the blood that filled the veins. The connection between the arteries, filled mostly with *pneuma*, and the veins, filled mostly with blood, was through the air that was in both.[56] The blood was the origin of the flesh. The *pneuma* was from the air outside and from the air given off by the nutriments ingested. He thought that the arteries that originated from the heart were channels that contained the breath, and they were the source of motion in the limbs. The arteries became increasingly small as they ran through the body to the organs, so they were unable to be seen. These distal fibers he called *neura,* a word that had previously meant sinew.

Praxagoras identified the pulse as a specific feature of the arteries, and he used it as a diagnostic tool to separate the natural motion from the pathological. His complete reliance on the humors to explain disease is seen in his views of paralysis, epilepsy, and apoplexy.

Praxagoras described the cause of epilepsy as a problem with the *pneuma*:

> The cause of epilepsy. Praxagoras says that epilepsy is engendered in the region of the aorta by the aggregation of phlegmatic humors

> in it. These, formed into bubbles, block the passage of the psychic *pneuma* from the heart, and thus the *pneuma* makes the body shake and convulse. When the bubbles have disappeared, the attack is over. Diocles also believes in an obstruction in the same place, and, as regards the remainder of the process too, he is of the same opinion as Praxagoras. It is true he omitted the specific cause, but, in his account of the disease, he says that it must be referred to obstacles to the *pneuma* which were difficult to overcome.[57]

Praxagoras said that apoplexy also originated in the region around the aorta and was caused by cold and thick phlegm, which completely blocked the passage of *pneuma* into the aorta; there was complete suffocation.[58] He used the same pathology to explain paralysis, which was also caused by thick and cold phlegm that accumulated in the arteries from the heart so that the *pneuma* was blocked and there was no voluntary motion.[59] Apoplexy was distinct from paralysis because the whole body was weak in apoplexy but only a part in paralysis.[60] Praxagoras was the only physician of his day to describe neurosis, which sometimes caused the hands or head to shake.[61] Praxagoras said that mania was engendered by a swelling of the heart, where thinking also takes place, as he believed.[62] Galen criticized him for not knowing as much as he should about the brain:

> Thus I am astonished not only by the absurdity of the opinions held by the pupils of Praxagoras and Phylotimus but also by their ignorance of the facts revealed by dissection. They believe that the brain is a kind of overgrowth and excrescence of the spinal cord and that for this reason it consists of long convolutions. The posterior part of the brain, however, which is the continuation of the spinal cord, does not at all show such a structure, whereas the frontal part shows it clearly and to a great extent.[63]

Praxagoras served to make the transition from the earlier vague structural concepts to the more concrete anatomical observations of Herophilus. The medical book of Herophilus (330/320 to 260/250) comes

to us entirely as fragments and testimonia from later authors.[64] But, even with only oblique sources, his presence and influence on the knowledge of neuroanatomy is undiminished. Herophilus was active at the beginning of the third century. He made contributions to pulmonary, reproductive, and gastrointestinal anatomy, but the first book of his *Anatomy*, known only indirectly (there is no existing text), was on the brain and nervous system. He identified structures of the nervous system and named them with a level of detail clearly the result of his experience with dissection and probably vivisection of human beings.

Like Aristotle,[65] Herophilus separated the the cerebrum and the cerebellum and described the main ventricles of the brain, making the fourth ventricle the seat of the intellect. He described the floor of the fourth ventricle, comparing the indentation in the brainstem to the cavity in the ink pens used by the scholars in Alexandria, so we still have the term *calamus scriptorius* in our anatomy books. We also have the *torcular herophili*, which he identified as the confluence of the cerebral veins that reminded him of the reservoir of a wine press, *lenos* (or from Latin "torcular"). Herophilus called the three membranes of the brain "chorioid" because they resembled the chorionic membranes of a fetus.

Galen told what he knew about Herophilus's views on the ventricular anatomy of the brain and the importance of the cerebellar ventricle:

> Now since all the nerves going to the body below the head grow either from the cerebellum or from the spinal cord, it was necessary for the ventricle of the cerebellum to be of quite a considerable size and to receive the psychic *pneuma* which had previously been prepared in the front ventricles. Thus there had to be some passage from anterior to the ventricle in the cerebellum. This ventricle is large, but the passage entering into it from the anterior ventricles is also very large indeed. It is through this passage alone that the cerebellum is connected to the cerebrum.
>
> Since the cerebrum is separated from the cerebellum, as has also been stated previously, by the fold of the thick membrane [*tentorium]*

> but needs to be attached—even if only at a single part—for the sake of the formation of the above-mentioned passage—the cerebrum has brought both its ventricles to a termination in one place (now third ventricle), which some anatomists count as a fourth ventricle of the entire brain.[66]

> Those who have considered this cavity (third ventricle) to be a sort of fourth ventricle, say that it is the most important of all of the ventricles throughout the whole of the brain. But Herophilus thinks that not this ventricle, but the one in the cerebellum is more important (our fourth).[67]

Herophilus also saw the brainstem and described the floor of the fourth ventricle. Galen described the dissection:

> Next pay attention how, when the vermiform process is bent forwards, the result is that the posterior ventricle of the brain, the fourth, is exposed, and when it is moved the opposite way the greatest portion of the ventricle is covered and only that part is visible which Herophilus likened to the cavity in the pen (*kalamos*) with which we write. It is really so: it has a kind of hollow in the middle like an incision and on either side of it each of the two lateral parts stretches upwards to as great a height as it rises in pens from the middle line. They carve out the pens we write with in this fashion especially at Alexandria. Herophilus lived there so it is likely, I suppose, that when he was dissecting he invented this name influenced by the similarity of the image.[68]

Although he described the confluence of sinuses or torcular herophili, there is some suspicion that Herophilus based at least some of his anatomic description on animal dissection because the fully developed torcular is not present in all humans but is universal in the ox, a favorite specimen for the anatomists. Also, he described a *rete mirible* at the top of the carotid arteries, which exists only in animals.[69]

His most impressive achievement in neuroanatomy was the identification of the peripheral and cranial nerves that connect to the brain to allow motion and sensation.

Galen was the source for our information about the cranial nerves through an Arabic text on dissection:

> For many surgeons do not know that in his work on the roots of the nerves Marinus has enumerated only those same roots which Herophilus specifies, but Marinus has concluded that there are seven pairs, whereas Herophilus says there are more than seven, regardless of the others.[70]

Rufus of Ephesus told about the notions held by Herophilus and Erasistratus in their anatomy of the nerves, as discussed in Chapter 9.

While explaining tremor, Rufus also said that Herophilus attributed the pulse to involuntary movements in the heart and arteries, which were the only source of pulses. Tremor and spasm were different from pulses because they occurred in the muscles and nerves only and were independent of being alive, unlike the pulse.[71]

Herophilus's view of physiology is not clear from the extant sources, but he seemed to accept the standard concept from Praxagoras of the *pneuma* transmitted in the nerves. He is credited for believing that the optic nerve was a hollow conduit for the *pneuma* going to the brain. That he could have been looking directly at the optic structures and be so wrong in his interpretation of the physiology based on airflow suggests that earlier bias from the prevailing assumptions filled in what his observation could not discern.[72]

Galen implied in his criticism of the physiology of Herophilus that he had no clear concept of a cause or other physiology existing beyond the nerves. The point remains obscure, but there is no doubt that Galen credited Herophilus with the separation of motor and sensory nerves.[73] The assumption is then that Herophilus used a limited concept of *pneuma* but did not develop a comprehensive mechanism for the actual activity of the organism because his evidence came from observed structural

parts of the body only.[74] At any rate, one of the ancient controversies of medical–philosophical thought was resolved: Herophilus documented that the nerves linked the source of motion and perception to the brain and spinal marrow.

Herophilus identified the brain as the seat of cognition, in opposition to Aristotle and his own teacher Praxagoras, who put it in the heart. He placed the central command in the fourth ventricle of the brain and perhaps the cerebellum as Galen reported: Herophilus placed the controller, *hegemonikon*, "in the hollow of the brain which is also the base."[75] One must be somewhat cautious in assuming that Herophilus determined the controller to be related to the cerebellum[76] rather than to the structures at the floor of the ventricle, which would, if damaged, create more dramatic changes in motor and cognitive function compared to the rather uninteresting roof of the fourth ventricle. Moreover, the cranial nerves III and IV are the only ones that are above the fourth ventricle. But, Galen accepted Herophilus's localization based on his own animal experimentation.

Herophilus advanced medical knowledge but did not develop a new methodology of medical practice. He applied the old methods, inspection and supposition, but he had a better view of the anatomy. The fact that his physiology remained fixed on the concepts of *pneuma* and the humors shows the limits of the Hellenistic understanding of pathophysiology.[77]

Erasistratus,[78,79] a contemporary of Herophilus and a disciple of Praxagoras, left little to allow our understanding of his thought. Galen indicated that he focused his pathophysiology, as taught by Praxagoras, on the *pneuma* and on the digestion of food that allowed blood to be produced. According to Erasistratus, if there were an excess of blood in the veins, it would be transferred to the arteries where, as a *plethora*, it interfered with the dissemination of the *pneuma*. The treatment for diseases that caused an excess of blood or inflammation was restriction of food.[80] He believed that the *pneuma* was carried by the nerves, and they were so tiny that they were invisible. He may have identified the dura mater as the site of the *hegemonikon* in the brain because he saw the nerves coming from it.[81] He also thought that apoplexy (stroke) was a brain pathology, and that phrenitis was a problem with the meninges.

Galen described the views of Erasistratus about the brain and how he changed his view based on further study:

> Erasistratus, who for a long time saw only the outer part of the nerve, [the part] that comes from the dura mater, thought that the whole nerve grows from that source, and most of his writings are full of statements that the nerves grow from the meninx that encloses the brain. But when, late in life and at leisure to devote himself entirely to the study of the art, he performed his dissections with greater care, he recognized also that the heartwood, so to speak, of the nerves grows from the brain. He writes as follows: "We viewed also the structure of the cerebrum, and it was bipartite, as in the other animals, and there were ventricles lying there, elongated in form. The ventricles were united by a perforation at the point of contact of the parts. From this point a passage led to the so-called cerebellum, where there was another small ventricle. Each of the parts had been partitioned off by the meninges. For the cerebellum had been partitioned off by itself, and also the cerebrum, which is similar to the jejunum and has many folds; and the cerebellum, even more than the cerebrum, was provided with many varied convolutions. So the observer learns from these that as it is in the other animals—deer, hare and any other that far excels the rest in running being well provided with the muscles and sinews useful for this activity—, so in man, since he is far superior to the other animals in thinking, this [part] is large and has many folds. And the outgrowths of the nerves were all from the brain; and by and large the brain appears to be the source of the nerves in the body. For the sensation that comes from the nostrils passed to this organ through apertures, and also the sensations that come from the ears. And outgrowths from the brain went also to the tongue and the eyes."
>
> In these words Erasistratus admits that he then saw clearly a thing that he had not known earlier, that each nerve grows from the brain.[82]

The establishment of an empirical method to study the cause of health and disease led to the progress in neuroanatomy made by Herophilus and

Erasistratus, but there were major gaps in the understanding of the physiology and pathology that played out on the newly defined structures. The control center of the body was better established, although Galen found it necessary to applyhis vitriol refuting later medical writers who continued to put the heart at the lead.

The third century BCE was a time of innovation and advancement in many aspects of scholarship. The political and intellectual components worked together to allow new waves of thought and breakthroughs in literature, science, and medicine. The advances in neuroanatomy and medicine were part of that larger revolution that did not stall until the early part of the second century. Despite the new knowledge uncovered in the Hellenistic period, the later practice of medicine devolved into a feckless array of contested opinions. Polybius, the Greek historian who lived in Rome in the middle of the first century BCE (fl. 170), provided an insight into the subsequent state of medicine that developed after Herophilus and his school had waned:

> The study of the theory of disease, which is derived chiefly from the schools of Herophilus and Callimachus at Alexandria, is indeed an integral part of medicine, but as regards the ostentation and pretensions of its professors, they give themselves such an air of superiority that one would think no one else was master of the subject. Yet when you make them confront reality by entrusting a patient to them you find them just as incapable of being of any service as those who have never read a single medical treatise. Not a few invalids indeed who had nothing serious the matter with them before have now come very near losing their lives by entrusting themselves to these physicians, impressed by their rhetorical powers.[83]

NOTES

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5. Lloyd, G. E. R., "Hellenistic Science: Its Application in Peace and War," in Walbank and Astin, *Cambridge Ancient History*, vol. 7, pp. 321–383.
6. The expulsion of the intellectuals in 145/144 caused a migration throughout the world as documented in Athenaeus, *Deipnosophistae*, 4.83.184b–c, von Staden, Heinrich, *Herophilus: The Art of Medicine in Early Alexandria*, Cambridge University Press, Cambridge, MA, 1989, pp. 67–68.
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20. von Staden, *Herophilus*, p. 523.
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25. Theocritus, *Idyll* XI 5–6.
26. Callimachus, *Hymn* III 53–54.

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28. Most, G. W., "Callimachus and Herophilus," *Hermes* 1981; 109:188–196. Von Staden took issue with the conclusion that the birth technique was attributable to Herophilus.
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39. Green, *Alexander to Actium*, p. 484, quotes Phillips, E. D., *Greek Medicine*, London, UK, 1973, p. 140.
40. von Staden, *Herophilus*, p. 141.
41. von Staden, *Herophilus*, p. 149. See Diodorus Sicculus, I.91, 1–4. The exact level of vilification is in doubt.
42. Celsus, *De Medicina*, Loeb Classical Library, Spencer, W. G., ed., Harvard University Press, Cambridge, MA, 1935, "Prooemium," 23–26, pp. 14–15.
43. Tertullian, De Anima 10. 4, pp. 13,2 T66. Retrieved from http://www.tertullian.org/works/de_anima.htm see also Holmes, P., ANCL 15 (1870), pp. 410–541; reprinted ANF 3 (1885), pp. 181–235. In Ante-Nicene Christian Library, vol. 7, *Tertullianus Against Marcion: The Five Books of Quintus Sept. Flor. Tertullianus Against Marcion*, trans. Peter Holmes, T&T Clark, 1868, 496 pp. Also in von Staden, *Herophilus*, p. 190.
44. The Latin comes with somewhat less emotional impact, but he was not pleased: "Herophilus ille medicus aut lanius, qui sexcentos exsecuit, ut naturam scrutaretur, qui hominem odiit, ut nosset, nescio an omnia interna eius liquido explorarit, ipsa morte mutante." *from* Waszink, J. H., *Index Verborum et Locutionum Quae Tertulliani de Anima Libro Continentur*, Bonn, Germany, 1935.
45. Galen, *De Antidotis* 1.1(XIV, p. 2K).
46. von Staden, *Herophilus*, p. 138ff.
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59. Steckerl, *Fragments of Praxagoras*, frag. 75.
60. Steckerl, *Fragments of Praxagoras*, frag. 73.
61. Steckerl, *Fragments of Praxagoras*, frag. 71.
62. Steckerl, *Fragments of Praxagoras*, frag. 72.
63. Steckerl, *Fragments of Praxagoras*, frag. 15.
64. von Staden, *Herophilus*, pp. 195–208.
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69. von Staden, *Herophilus*, p. 121; Galen, *Use of the Pulse*.
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72. von Staden, *Herophilus*, 86.
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11

The Hippocratic *Oath* and a Modern Digression

Our customs and laws hold a physician personally responsible for the competent, ethical, and humanitarian treatment of the individual patient. A physician is expected to practice altruism, suspend self-interest, and ensure trust when delivering medical care. A physician must provide medical care that meets the standard of competence that prevails in the community or the physician is liable to a charge of malpractice. The Hippocratic *Oath* is widely regarded as an ancient mantra that expresses a well-intended, voluntary commitment of a physician to the best practice of the profession and best treatment of patients. Mention the *Oath* and it will conjure a call to ethical behavior, good clinical practice, and a guarantee of a good experience for a patient independent of any pressing legal exposure. The *Oath* that has come from the Greeks is much more nuanced than the popular assumption.

This discussion describes the Hippocratic oath and its origins, identifies the major scholarship done on the oath, discusses the context in which the oath first appeared, reviews the modern attitude toward the oath, and comments on its role in the affirmation of a physician's responsibility in the current medical marketplace.

The *Oath* as a template for medical behavior

Graduates in medicine who recite an oath called "Hippocratic" rarely swear by anything like the original. The Greek words that give the original oath its ethical durability are lost to most modern doctors, who invoke the *Oath* as a general mantra to symbolize their commitment to being a good doctor. The literal translation here establishes the content of the oath without a modern interpretation or smooth English syntax:

Hippocratic *Oath*

I swear, by Apollo the physician, and by Asklepius by Hygeia, by Panacea, and by all the gods and all the goddesses,[1] making them witnesses, to fulfill this oath and this contract according to my power and judgement.[2]

To consider the one who taught me this art equal to my parents and to share a life in common and if he should need resources, to provide [my] share; to consider his sons the same as my brothers and to teach them this art, if they need to learn it, without pay or obligation, both the rules and the commentary and all the rest; to include my own sons and those of my teacher and also students who sign and swear the physicians vow, but to no one else.

And I will provide dietary regimens for the benefit of the sufferers according to my ability and judgment and I will keep them from harm and injustice. I will not give a deadly drug even when someone demands it, nor will I suggest this type of treatment plan. Similarly I will not give a harmful pessary to a woman.

I shall maintain my own life and my own art purely and devoutly.

I will not take up the knife even in the case of stone; I will defer to those men employed for this practice. And in whatever homes I enter I will come to help the sufferers, keeping separate from all things purposefully unjust or harmful, and in particular from acts of lust toward the bodies of women and men, both the freemen and the slaves. If I should see or hear things in the course of my practice

or even outside my practice about the life of men, I will keep silent about those things which it is not necessary to broadcast, considering that these things are not to be spoken.

Now if I fulfill this oath and do not break it, may I reap, in my life and practice, renown among all men for all time. If I swear falsely and transgress, may I reap the opposite things.

THE ORIGIN OF THE HIPPOCRATIC *OATH*

The Hippocratic *Oath* was transmitted in the manuscripts of the ancient Greek medical works, the *Corpus Hippocraticum*. The date remains a conjecture between the fifth and fourth century. It avowed a new physician's loyalty toward his teachers and colleagues and defined the rules of medical etiquette. *Physician,*[3] *Precepts*,[4] and *On Decorum*[5] are later deontological works from the *Corpus Hippocraticum* written in the postclassical period that were also guides to the practice of medicine. The later texts amplified the notions of ancient medical etiquette but have not remained as influential as the *Oath* in modern medical awareness. The life and work of Hippocrates remains an enigma, but he was an active doctor in fourth-century Athens; tradition holds that he taught and studied at Cos, where there was probably a medical sect or school.[6] The *Oath* may have originated at the Coan School, but Hippocrates probably did not write it (see Chapter 2 also).

The Oath is the shortest document we have in the *Corpus Hippocraticum*, so it contains scarce textual information from which to draw conclusions about its date, origins, and use.[7] Based on the scholarship of the last several decades, we can determine that the Hippocratic oath was likely written in the latter fourth century BCE over 2,000 years ago, but the precise date remains a conjecture. There are some clues to the approximate date. The text contains ideas of Philolaus, a contemporary of Plato and a key source of Pythagorean thought,[8] which set a *terminus post quem* around the end of the fifth

century.[9] The *Oath* was listed by Erotian, the first century CE lexicographer, as contained in the ancient Hippocratic collection.[10] Our source for the *Oath* has come in two Greek manuscripts—*Marcisanus Venetus* (M) from the 11th century CE and *Vaticanus Graecus* (V)—from the 12th century CE and was written in Ionic dialect like the medical texts in the *Corpus Hippocraticum*.[11]

There are several collations of the Greek manuscripts, and among the many English translations, there are four that are best known. Francis Adams, an American physician, provided a familiar translation that he published in 1849 based on Littre's text.[12] W. H. S. Jones provided a critical text and translation in 1923 in the Loeb Classical Library.[13] Modern scholarship on the oath has been influenced for years by the translation and commentary of Ludwig Edelstein,[14] published in 1943. Heinrich von Staden recently published a literal translation and commentary on the *Oath*.[15] Each of these translations contains the basic thoughts of the Greek author rendered in the English used at the time. The commentaries reflect the scholarship as interpreted by the author.

Ancient physicians may have known about Hippocrates and his works, although all do not mention him in their writings. A physician's duty for ethical care of the patient had been a goal defined by doctors even before Christianity overwhelmed the pagan culture. Scribonius Largus, a pagan physician of the first century CE, cited the *Oath* as an example of the behavior required by medical practice, which he called *professio*.[16] He expected a physician to maintain "sympathy and compassion" toward patients, a responsibility that separated the medical craft from the carpenters. The ethical dictates of the *Oath* were not specific enough to define a physician's responsibility as required by Scribonius Largus, but he saw it as a beginning.[17] The changes in medical practice that continue today also encourage adoption, expansion, and reemphasis of the basic outline found in the original oath.[18] Galen (second century CE) was incapable of assigning a higher responsibility to the physician than being a medical expert. He felt that any philanthropy was merely a side effect of the physician's success rather than a direct aim,[19] a view that would not allow assent in today's medical world.

CONTEXT AND INTERPRETATION OF THE *OATH*

In the fourth century BCE, most medical practitioners did not abide by the Hippocratic oath, and it was probably a parochial text that found its way with marginal popular acceptance into the *Corpus Hippocraticum*. Within its limited audience, the Hippocratic *Oath* required the oath taker to swear to a defined responsibility and to a stricter moral constraint than was general in the medical community. There is no doubt that Greek medical practice violated every tenet described in the *Oath* because each was stated explicitly. It is also true today that our modern medical regulations are developed to address the transgressions that are known to be likely in the profession.

The Hippocratic physicians were not temple practitioners, although they were known as Asclepiads. They were separate from the healers who worked as priests in the shrines of Asclepius. Despite the appeal to the gods, the brotherhood assumed in the *Oath* is secular, personal, and removed from the priesthood associated with temple medicine. The religious origins of medicine and magical thinking continued to influence the ancient medical practice, but the Hippocratic physicians edged toward rationalistic explanations despite their gross misconceptions of physiology and their failures.[20] The earliest medical men were thought to have been endowed with the healing powers by the gods, especially by Apollo. Asclepius was the earthly manifestation of the god's power to heal, bridging the tradition between natural and supernatural medical practice. There were temples to Asclepius in Greece where the priests used prayer, incantations, and incubation (dream treatments) to produce a therapeutic effect.[21] The religious practitioners were probably as successful as the medical practitioners in many cases, and they likely incorporated the secular medical techniques as they became available.

In the beginning, Greek physicians belonged to and were trained by their Asclepiad families, who had passed the skills from generation to generation. By the time of Hippocrates, there may have been a need to open the medical craft to members outside the family, perhaps because, as some later accounts supposed, the number of new physicians coming

from the medical clans had diminished.[22] The *Oath* was a document that is sworn by those who were not from the family and who were brought into the training program to become "like family." The fealty sworn by the *Oath* to the teacher was a protection for the Asclepiad family to maintain loyalty as it would be if family ties remained the basis for inclusion.[23]

The Greek physician was a tradesman and felt the pressures of the marketplace as did the other craftsmen.[24] Although the physician could point to Homer for validation of his medical value,[25] he was included as a tradesman by Aristotle, who named carpenters and physicians in the same phrase as examples of specialists.[26] The physician's motivation was to be successful in his *techne*, translated as "craft" and later as "art," so his business would thrive. The word *techne* included diagnosis, treatment, and prognosis but did not indicate a position beyond the ordinary craftsman. The skill of the stonemasons and the potters was also *techne*. Gradually, the Greeks began to inflate the *techne* as a special ability of the physician to relieve suffering and to prognosticate.[27] Von Staden argued that the use of *techne* was a lexical marker of the special expertise expected of the physician in the oath.

Ludwig Edelstein made a carefully reasoned but overstated[28] argument that the *Oath* was probably a Pythagorean text. The Pythagoreans would be expected to forbid a physician from aiding suicide and performing abortion, which were practiced routinely by other physicians in fourth-century Greece. Later scholars argued that the proscription of causing death by poison actually included murder as well as suicide, an interpretation that weakens Edelstein's Pythagorean hypothesis.[29] There may have been a more generic group of physicians influenced by the prevailing ethic of the community, as well as the Pythagoreans, who were behind the *Oath*.[30] There was little scruple against abortion or even infanticide in the ancient world until the beginning of Christianity. Edelstein made a compelling point[31] that the addition of the ban on abortion in the oath was a mark of a rather narrow belief base. But, as Kudlien pointed out, beside the Pythagorean taboo against abortion, there were more general religious prohibitions related to "uncleaness" associated with miscarriage, which required days of purification and other ritual to escape it.

A wider Greek religious belief, including the general prohibitions, may have influenced the author of the *Oath* to proscribe abortion.[32] There were other objections to the argument that a Pythagorean cult was the origin of the oath, but some controversy remains.[33]

The mercantile aspect of ancient Greek medicine was unrestrained, and the physicians marketed their skills as brazenly as do our hospitals and medical businesses do today. Just like the other physicians of the time, Hippocrates earned a fee for his medical services and teaching either individually or as a physician on the city's payroll.[34] The ancient physician could benefit some patients, despite his gross misunderstanding of pathophysiology, using observation and experience to guide management, but the best physician could make a prognosis and knew when not to take a case so he would not be saddled with a failure.[35] There were no hospitals, no credentialing, and no boards of registration or licensors; the physician's reputation for skill in practice was based on his public relations, and the only restraints on the physician's practice were his own skill and his personal values. The *Oath* outlined a contract governing the physician's relationship with his peers and his patients.[36] The *Law,* another Hippocratic text that also defined a physician's behavior, described a negative attitude toward physicians and the lack of regulation which failed to constrain incompetence (See chapter 6).[37]

The personal ethical relationship to the patient found in the oath, as von Staden documented, widened the commitment of "doing right" to all aspects of the physician's life. The *Oath* demanded that the oath taker conduct his life in a "pure and holy way,"[38] the indication recognized by Scribonius Largus and other physicians as a statement of personal ethics. Ancient Greek physicians did whatever they thought was effective to ward off disease and resorted to treatments, such as toxic drugs, the knife, and cautery, that could be dangerous. There was of course every compunction to protect the patient from an ill effect of the treatment so as to remain a credible physician. The *Oath's* promise to keep the patient from "harm and injustice" seems otiose on the surface, but it may have reflected the perception of the inherent danger of Greek medical practice and the peril to the patient of his own poor judgment in failing to follow

the therapeutic plan. The mandate also included protection for enemies of the society that in the ancient world were not deemed worthy of medical care.[39]

MODERN USE OF THE HIPPOCRATIC *OATH*

The Hippocratic *Oath* is usually invoked as a model for medical practice with only perfunctory knowledge of its origin or its literal content.[40] Commentators have declared the *Oath* outdated,[41] too mythical or not rightly religious,[42] too specific to use,[43] or not inclusive of the complexities in modern practice.[44] Despite the ignorance and objections, it is still cited as an ethical standard, at least in name, and there remains esteem in its value.[45] The *Oath* has been trivialized and parodied to illustrate current difficulties that physicians have with systematic healthcare management,[46] and it has been rewritten beyond recognition to accommodate the beliefs of groups that take issue with what the original says.[47] The ancient, unmodified, Hippocratic *Oath* has been used in the past by some graduating physicians in Europe and North America, but that use is long over.[48]

When invoked as a template for physician behavior, the "Hippocratic oath" conjures generalized ideals of a doctor–patient relationship and a doctor's "dedication" to the profession and patients. Modern use has tried to adapt the good intent and tradition of the ancient oath, but in almost all cases the ancient words are replaced, the tone diminished, and its ideas expanded or dropped as dictated by local and parochial attitudes.[49]

The original Hippocratic *Oath* is not now uttered by medical graduates, and the various oaths called "Hippocratic" are usually written by the institutions using them. Most medical schools have their new doctors recite an ethical statement or oath of some kind at graduation to establish publicly the call to a moral and fair practice of medicine between physicians, patients, and society.[50] In some cases, there is an attempt to allow the students themselves, despite never being a doctor and probably not a patient, to produce their own interpretation of an oath that fits with their personal and social context. They can develop an oath consistent with

their situation and that expresses their view of medical ethics as they wish to practice it.[51,52]

The graduates who receive the MD degree, unlike those who attain the MBA, are supposed to embrace a purpose beyond profit and self-interest. They are encouraged to direct their practice through advocacy for the patient, although the modern reality of programmed medicine is driving physicians far from the control of their profession. There is no single physician's oath used today.[53] Each medical school develops its own set of values to be sworn by its graduates and generally fits these values into a statement loosely based on the Hippocratic *Oath* or some variant, such as the short oath of Maimonides dating from the 18th century CE, which is used in some medical schools at graduation.

MODERN OATHS

The changes in medical practice over the last few decades that question the importance of medical oaths have generated controversy about the Hippocratic *Oath* and its progeny.[54] Commentators and oath writers moved to modernize the Hippocratic oath and to expand the scope of the medical oath to include everything germane to medical ethics. The attempt produced oaths containing lists of rules to guide the neophyte physicians.[55] The British Medical Association offered a lengthy graduation oath that was broadly based and detailed in its specific promises. The Declaration of Geneva, first developed in 1948 and subsequently amended, set out a list of promises based partly on Hippocratic ideas but expanded to include a doctor's responsibility to humanity in general.[56] Some efforts to dismiss the original and to fit a modern oath into a Hippocratic model were based on misunderstanding of the ancient context, obsolete scholarship, and a positivistic approach that neutralized the Greek meanings.[57] Other commentators confirmed the importance of the original *Oath* despite its being couched in words easily misunderstood in a modern context, and they embraced the original *Oath* as having merit even today.[58]

The Hippocratic *Oath* promises, in the most general way, to keep the patient from "harm and injustice" or in other words declares that a doctor must maintain the patient's well-being first.[59] Societal and legal responsibilities, research ethics, or teamwork of a modern physician might be implied by the broad value of protecting the patient from injustice; any list of specific items would be incomplete, and the ethical mandate would depend on the time, place, and context of the doctor–patient encounter. Adding promises, however, that generalize the doctor–patient responsibility to the whole of society dilutes the highly personal responsibility of the physician to each one of his patients. Prohibiting a doctor from participation in war crimes, a promise easier to keep than a promise not to perform euthanasia, is tacitly included in the essential precept of the original oath that advocates protecting the patient's interest. A physician, who receives extraordinary access to another individual's life, promises in the *Oath* to practice medicine honorably as an individual without abusing his special confidence.

A graduation oath dictates a physician's extraordinary duty to individuals, person to person, rather than a broader legal or regulatory responsibility to society or humanity in general. A graduation oath that tries to include all the rules of a profession is cumbersome and redundant and rapidly becomes meaningless as the art and science of medicine change. The fourth-century Greeks were not politically correct by our standards, so they had no need to profess a concern about the rest of "humanity" or about "equality" or even to mention females as doctors. They constructed instead a working and personal relationship between an individual physician and his patient. The ancient Hippocratic *Oath* is quiet about societal and universal commitments that would reduce the physician's personal burden and would make the more diffuse oath a grand but empty gesture. The Hippocratic *Oath* is not specific for modern use, but it forms a general framework that can be used at any time and any place.

Oaths, pledges, and guidelines have come and gone as the ethics of medicine have been pondered and codified over many years by doctors, lawyers, and legislators. The American Medical Association (AMA) developed rules and values for medical practice in a document[60] that has

been used and revised since 1847. There are also specific legal and societal constraints on medical practice that are not part of a voluntary covenant that comes with a medical license.

Oaths, which are voluntary promises, are constructed with elements that make them meaningful to those who swear them. Any oath, using traditions of the community, appeals to a higher authority (often a deity of some sort) to witness and to validate the commitment of the promise. An oath is written with a gravity that elevates its importance and establishes credibility by including the burden of retribution should one breach it.[61] Without the consequence of default, an oath is no more than a recitation of a company slogan without emotional and spiritual importance. The characteristics that define an oath have been described by Sulmasy:

> Oaths, like promises, are performative utterances. But oaths are generally characterized by their greater moral weight compared with promises, their public character, their validation by transcendent appeal, the involvement of the personhood of the swearer, the prescription of consequences for failure to uphold their contents, the generality of the scope of their contents, the prolonged time frame of the commitment, the fact that their moral force remains binding in spite of failures on the part of those to whom the swearer makes the commitment, and the fact that interpersonal fidelity is the moral hallmark of the commitment of the swearer.[62]

CHANGING THE DOCTOR'S ROLE

During much of the last century, physicians in the United States were financially autonomous and could provide service at a price they chose. They were esteemed as beyond the commerce of other businesses and therefore were entrusted to set their fees. Physicians controlled the practice of medicine and could choose medical resources with little economic constraint. Over the last 30 years, the role of the modern physician has changed dramatically as business management has become the backbone

of the medical care system. Physicians have been gradually reduced to technicians, compelled by outside mandates, constrained by committees, and redefined as interchangeable members of a "healthcare team." Physicians are no longer independent in managing the numerous competing interests between patients and those who pay the cost. A physician must seek "authorization" for diagnostic and therapeutic decisions and may be required to ask directly for permission to order a test in a "peer-to-peer" conference with a representative of the payer who must agree to pay for the clinical request. The physician has become one type of "provider" in the business of medicine; his managers have made clear the delineation between who is and who is not in charge. The advent of a "physician appreciation day" arranged by hospital managers is a new ritual recognizing the subaltern physicians as "valuable" members of the team. A few lectures, a free meal, and babysitting are included as the gift from the management.

The huge cost of medical care, especially in the United States but elsewhere also, is driven by technology and management expenses that have preempted any casual reimbursement system. Transplants (heart, lung, liver, kidney, and even face), intensive medical care in a special unit (ICU), imaging of every organ, and other life-saving procedures are expected, no matter the cost, by everyone who may require them. The advances in medical technology that have increased the expense of health care have created a dilemma for physicians responsible for providing health care for individual patients. Patients do not pay for their health care directly, a situation that removes nearly all consumer restraint from their demands for services. The doctor and the patient may have the same goal of good health, but their expectations about the consumption of medical resources can be in conflict. Political, economic, and personal constraints to save money permeate the physician's decisions about delivering medical care to individuals. If the physician loses income or reduces his provider "tier status" by costing the insurer too much money, the physician must restrict the use of technology and thus may fail to satisfy the patient's expectations. If the physician fails to make the correct diagnosis, he can be sued. The risk of litigation is a powerful force that encourages use of expensive technology; especially when the physician is weak in clinical skill, the need for technology increases.

Despite the dilemma of best care and best business, the physician remains, at least for now, the patient's advocate and is expected to deliver high-quality medical care and maintain an extraordinary ethic of "professionalism."[63] The devolving role of the physician from "doctor" to "employee" threatens the high-mindedness of the profession and breeds reluctance for extraordinary service. As the physician becomes one operator in the service line of providers, the rules of conduct tend to be dictated from external power and less from an innate sense of professional responsibility. We do not require other hospital employees who comprise the healthcare team to swear an oath to do the right thing in their jobs: We have rules and regulations governing their conduct; the same hospital regulations apply to physicians who are seen as personnel units by the human resources manager. Physicians may eventually fail to see themselves as innately responsible, above the regulated behavior and legal liability, for the patients' interests, just like the other employees on the team.

The harsh and grueling rites of passage in medical training that burned a sense of unrestrained duty in a physician are no longer tolerated. The doctor's old badge of selfless "dedication" and "devotion to duty," polished by spending inordinate work time taking care of patients, has been exposed as an unnecessary hardship on the medical trainees, just as for apprentices in other fields. An overworked, tired, resident physician is considered unsafe for patients and would increase liability for the employer. Young physicians in training are forbidden to work overtime in patient care at their own training program, although they can choose to work as much as they please elsewhere for money. There is no limit on duty hours for fully fledged doctors, who could also be overworked. There are, however, strict work limits for airline pilots.

The articulation of a physician's special duty to the patient has become muffled.[64] The special role of a physician toward a patient must be taught in medical school, and it is hard for the students to feel the special responsibility immanent in the profession when they see their mentors responding like robots to the edicts of government (meaningful use) or to the demands of payers to produce billing statements instead of medical records.[65]

The bond between a physician and a patient is a primary trust that is reviewed and remembered in the physicians' graduation oath. Individuals expect their physician to act with a level of personal behavior, epitomized at least in one form by the Hippocratic *Oath*, that allows trust and confidence in the care delivered. There may not be a practical need any more for an oath of ethics for the physician line workers because they are fully regulated and employed as a replaceable part of the larger team. At some time, however, those who are truly in charge of the practice of medicine, the MBA graduates, should stand an oath construed by society to be protective of the individual patient's interest. For now, the physician still takes personal responsibility for the patient, and the moral imperative, as declared by an oath, should provide the essential values of the profession to each physician and should demand the highest standards possible in the medical marketplace.

NOTES

1. Apollo is the god of healing and illness. Asclepius, his human son, became worshiped as the god of medicine; Panacea and Hygeia were his daughters.
2. The Greek text was translated from Jones, W. H. S., *Hippocrates* I, Loeb Classical Library, Harvard University Press, Cambridge, MA, 1923, p. 289. There are several translations available in English (e.g., Jones, Adams, Edelstein, Chadwick and Mann, von Staden). Louis Lasagna published a version in the *New York Times* on June 28, 1964, that is often used as a modern rendition.
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4. Jones, *Hippocrates* I, p. 303.
5. Jones, *Hippocrates* II, p. 267.
6. Lonie, I. M., "Cos vs Cnidus and the Historians," *History Sci* 1978; 16:42–75, 77–92; Smith, W. D., *The Hippocratic Tradition*, Cornell University Press, Ithaca, NY, 1979, p. 215ff.; Jouanna, J., *Hippocrates*, trans. DeBevoise, M. B., Johns Hopkins University Press, Baltimore, MD, 1999, p. 50.
7. Jones, *Hippocrates* I, p. 289.
8. Burkert, W., *Lore and Science in Ancient Pythagoreanism*, Harvard University Press, Cambridge, MA, 1972, p. 225ff.
9. Edelstein, L., "The Hippocratic Oath," supplements to the *Bulletin of Medicine*, no 1, Johns Hopkins University Press, Baltimore, MD, 1943. Reprinted in Temkin, O., and Temkin, C.L., eds., *Ancient Medicine*, Johns Hopkins University Press, Baltimore, MD, 1968, p. 56.

10. Nachmanson, Ernst, *Erotiani Vocum Hippocraticarum Collectio*, CUM Fragments, Eranos Forlag, Gotoburg, Sweden,1918; Temkin, O., *Hippocrates in the World of Pagans and Christians*, Johns Hopkins University Press, Baltimore, MD, 1991, p. 40.
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14. Edelstein, "The Hippocratic Oath," p. 6.
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16. Edelstein, L., "The Professional Ethics of the Greek Physician," *Bull History Med* 1956; 30:391–419, in Temkin and Temkin, *Ancient Medicine,* p. 339; Temkin, O., *Hippocrates in a World of Pagans and Christians*, Johns Hopkins University Press, Baltimore, MD, 1991, p. 43.
17. Edelstein, "Professional Ethics," 338–340; Temkin, *Hippocrates in a World*, p. 252.
18. Walton, M., and Kerridge, I., "Do No Harm: Is It Time to Rethink the Hippocratic Oath?" *Med Educ* 2014; 48:17–27.
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21. Luck, G., *Arcana Mundi: Magic and the Occult in the Greek and Roman Worlds*, Johns Hopkins University Press, Baltimore, MD, 1985, p. 141ff.; Edelstein, E. J., and Edelstein, L., *Asclepius*, Johns Hopkins University Press, Baltimore, MD, 1945 (pp. 139–180).
22. Rosenthal, F., "An Ancient Commentary on the Hippocratic *Oath*," *Bull History Med* 1956; 30:80. This is a collection of Arabic fragments attributed to Galen that date from the sixth century CE; the fragments discuss the origin of medicine, the opening of the medical schools to nonfamily, and some biographical information about Hippocrates.
23. Jouanna, J., *Hippocrates*, Johns Hopkins University Press, Baltimore, MD, 1999, p. 42–55.
24. Edelstein, L., "The Hippocratic Physician," *Peri aeron die Sammlung der Hippokratischen Schriften*, Chapter 3, Berlin, 1931, in Temkin and Temkin, *Ancient Medicine*, pp. 87–110.
25. *Iliad* XI, 514. "For the doctor is a man worth many others [to cut out arrows and to apply a soothing remedy]." The bracketed material was omitted in some collations.
26. Hett, W. S., trans., *Aristotle* VIII, "On the Soul" (403b1 line 14), Harvard University Press, Cambridge, MA, 1957, p. 17.
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30. Kudlien, "Medical Ethics," p. 91; Burkert, *Lore and Science,* p. 179.
31. Edelstein, "The Hippocratic Oath," pp. 14–19.
32. Kudlien, "Medical Ethics," p. 109.
33. Kudlien, "Medical Ethics," p. 107.
34. Lamb, W. R. M., trans., *Plato* II, "Protagoras" (311B), Loeb Classical Library, Harvard University Press, Cambridge, MA, 1924, p. 99.
35. Edelstein, L., "Hippocratic Physician"; Jones, *Hippocrates* II, "Prognostic," p. 7.
36. Edelstein, L., "The Professional Ethics of the Greek Physician," in Temkin and Temkin, *Ancient Medicine*, pp. 391–419.
37. Jones, *Hippocrates* II, *The Law*, p. 263.
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